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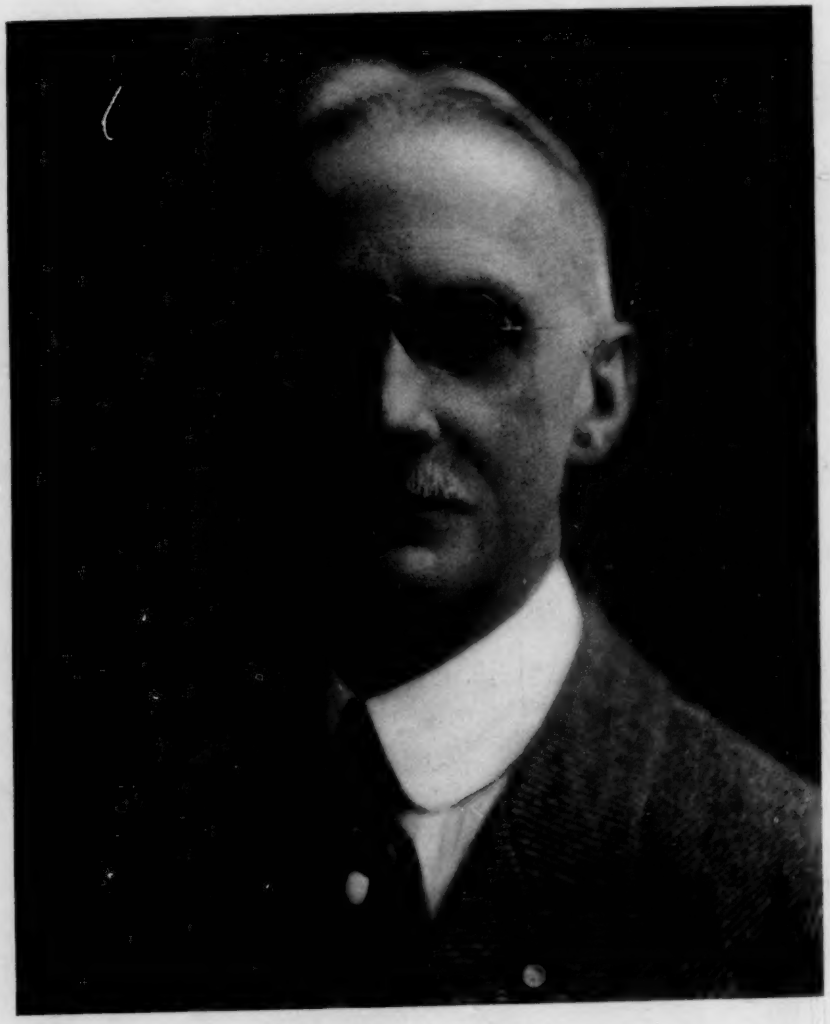

James Mark Baldwin.

1861–1934

VOL. 42, NO. 4 JULY, 1935

THE PSYCHOLOGICAL REVIEW

JAMES MARK BALDWIN

CO-EDITOR, PSYCHOLOGICAL REVIEW, 1894–1909

An appreciation of the life and work of James Mark Baldwin must take account of a figure of endless activity, embracing the work of the teacher, of the organizer of psychological research in its beginnings in America, of the mediator between the thought and culture of his own country and of France, and finally a literary activity covering a period of a quarter of a century—all of which has left its mark on the thought of his generation. His autobiography, entitled 'Between Two Wars, 1861–1921,' published in 1926, is an epitome of all the distinctive ideas of his time.

The professional life of James Baldwin coincides with the rapidly expanding development of psychology in America. In this development he played an outstanding part both as teacher and organizer. Academic positions of constantly increasing importance—at Lake Forest, Toronto, Princeton, Johns Hopkins, the University of Mexico and Paris—afforded him the opportunity of exercising a directing influence on the development of his chosen science. To this was added a still wider activity as organizer. Not only did he open up opportunities for experimental work in many universities, but he was instrumental, with others, in establishing institutions and journals which have become a permanent part of American psychology. He served on the first council of the American Psychological Association and was one of its early presidents. He was also active in founding the PSYCHOLOGICAL REVIEW in 1894, and its associated journals, the *Index*, *Monograph Supplements* and *Bulletin*.

Baldwin's life and work are in a sense an epitome of the evolutionary or Darwinian epoch in which he lived, and which he did so much to interpret. 'Darwin and the Humanities,' published in 1909, is at once indicative of the source of his past thinking and prophetic of the lines which his thought was still to take. In it he seeks to estimate the place of Darwin in the human sciences—psychology, sociology, ethics and religion, and to show "to what extent the principle of natural selection, as reinforced by organic selection, holds good in these subjects." His development of the notion of 'organic selection,' in cooperation with some of the leading biologists of his time, and the extension of this notion to the human sciences, was perhaps his outstanding contribution. Out of it grew his general notion of *genetic science* to the establishment and development of which he devoted the remainder of his life.

In the sphere of psychology proper, Baldwin's name is primarily associated with child psychology and social psychology. A pioneer in both fields, he gave to the world a series of books which were instrumental in shaping the development of both subjects. 'Mental Development in the Child and the Race,' 1894, 'Development and Evolution,' 1902, 'Social and Ethical Interpretations in Mental Development,' 1898, and 'The Individual and Society,' 1910, are titles which need merely to be mentioned in order vividly to recall the foundations of sciences which still retain the signs of his handiwork. It is for the specialists in these fields to say how much of the detailed experimentation and analysis in his works has entered into the permanent possessions of these sciences. This much can be said without question. They had a powerful influence in bringing about the abandonment of the older association and structural psychology in favor of functional and developmental views. The notion of genetic psychology, later to be extended to animal psychology (more particularly by John Watson, who was brought to Johns Hopkins by Baldwin) was fashioned in large part by his activity. No less significant was the influence of his principles of social psychology, perhaps his most lasting contribution to psychology.

Like his friend and colleague, William James, Baldwin partly lost his interest in psychology, in, as he writes, "the barrenness of the tables and curves coming from many laboratories." Philosophical interests came more and more to the front. These interests found expression in his monumental three volume work, 'Thought and Things or Genetic Logic,' which appeared in 1906 and 1911 and in his 'Genetic Theory of Reality, Pancalism,' 1915. As Baldwin's earlier work was an epitome of the Darwinian epoch, so his later work was an expression of the general 'philosophy of change,' of the 'taking of time seriously,' which followed upon this epoch.

A genetic theory of logic was a natural development from a genetic theory of mind. The revaluation of intellect and logic, in the light of Darwinian principles—of instrumental logic as developed by John Dewey and of Intuitionism as developed by Bergson—were prime concerns of Baldwin's more important contemporaries in philosophy. In this revaluation Baldwin played a conspicuous part. The extreme positions of his contemporaries tended to overshadow his more moderate and mediating views. The development of logic in the purely formal, mathematical direction has temporarily withdrawn interest from the philosophical problems of logic as contemplated by Baldwin. But these problems must inevitably come into the foreground again, and it is, perhaps, not too much to say that his careful analysis and his magnificent picture of logic and reason in its total functioning, will again have something to say to philosophy.

A genetic theory of reality was the culmination of the genetic logic. This is not the place to attempt either a presentation or an evaluation of this very original work. One thing may, however, be said. The doctrine of *genetic modes* is the first, and in some respects, still a classical presentation of what has come to be known as *emergent evolution.* "A truly genetic series is," for Baldwin, "irreversible and each new term or stage in such a series *sui generis*, a new mode of presence of what is called reality." Interpretation

of reality is the evaluation of the contributions of these various modes to our total picture of the real.

It is possible that the most significant aspect of Baldwin's life is that which can not be reconstructed from his printed works. As a mediating figure between European and American culture, he was one of the outstanding figures of his time. He became, for many, a sort of symbol of cooperative scholarship and science. When, after frequent sojourns in Paris, he finally took up his permanent residence there, this aspect of his activity increased in importance. His election in 1910, in succession to William James, to the Academy of Moral and Political Sciences in the Institute of France, brought him into personal relations with France's greatest minds and, both by lecturing and writing, he became an interpreter of American ideas to France. All this was intensified by the outbreak of the World War. His own personal involvement, through the injuring of his daughter in the torpedoing of the *Sussex*, intensified his emotional participation, but his long list of national and political studies which were the product of that time, are all on the highest level and reflect the innate idealism of the man.

The completed philosophy which Baldwin gave to the world is a form of idealism called 'Pancalism.' One of his latest writings, entitled 'The Beautiful World,' is an attempt to put in popular form the results of his technical philosophy. Æsthetic idealism, although a perennial form of philosophy, is not one that maintains itself easily. The forces of narrow rationalism, of pragmatic impatience, and of moral intensity are too powerful. In any case, it is perhaps the truest expression of himself. At the close of his autobiography he writes: "It will serve as the confession of faith of a sexagenarian who after a half century's experience, whose vicissitudes are narrated above, keeps his optimism if not altogether his serenity, and continues, even after the desolations both physical and moral, which have swept the world in the last decade, to have faith in 'Truth, Goodness and Beauty, the greatest of which is Beauty.'"

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SUBCORTICAL MECHANISMS IN LEARNING: I. THE FUNCTIONAL SIGNIFICANCE OF SUBCORTICAL NUCLEI IN CERTAIN SIMPLE LEARNING TASKS, WITH A DESCRIPTION OF A PROGRAM FOR FURTHER EXPERIMENTAL WORK[1]

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Recent experimental work on the neurological mechanisms utilized in problems of discrimination and learning tends to invalidate two of the traditional concepts of neurology: the localization of functions within specific regions of the cerebrum and the establishment of well insulated pathways in the nervous system during the learning of a given task. In the place of these concepts other explanatory devices have been substituted which more closely fit the experimental facts and leave remaining a smaller number of the proverbial exceptions. Most of this work has been limited to a study of the cerebral cortex and few direct attempts have been made to investigate the functions of subcortical centers. As a result of this neglect questions concerning the relative significance of cortical and subcortical nuclei in the performance of certain habits cannot be answered. The present paper is an attempt to bring together the known experimental facts concerning the functional importance of the subcortex in problems of discrimination and learning, and to briefly describe a program of experimentation directed toward obtaining a more adequate knowledge of the functions of the deeper nuclei of the cerebrum.

Three different types of experiment have yielded evidence on the functional significance of subcortical nuclei: (1)

[1] This article is the first of a series of studies on the functions of subcortical mechanisms in learning and discrimination being conducted in the psychological laboratory of the University of California.

demonstrations of the capacity for learning in decorticate specimens, (2) experiments in which subcortical nuclei were destroyed and the animal's capacity tested, and (3) experiments primarily directed toward a study of the cerebral cortex but in which incidental lesions to subcortical nuclei were involved.

Although a number of investigators have reported studies of the behavior of decorticate specimens, in which changes in postural and emotional responses have been meticulously recorded, few attempts have been made to study the animals' responses in typical learning situations. Goltz (**8**) endeavored to teach his decorticate dog to move backward out of his stall. No improvement was manifested after a number of trials, so practice was discontinued. Rothmann (**36**) taught a decorticate dog to walk on his hind legs behind a chair upon which his forefeet were being supported. This situation demanded more than the ordinary reflex movements of walking and so can be considered to have involved features of a learned response.

Most investigators have reported the absence in decorticate specimens of ability to recognize visual or auditory objects, although reflex movements to such stimuli usually have been easily elicited. Shaltenbrand and Cobb (**38**), however, report that their striatum cat showed signs of visually recognizing movements of the experimenter. When the experimenter walked around the animal at a distance of two meters or changed his position at five meters the cat followed him with her head and eyes. After some practice the cat walked toward the experimenter; but this response may have been to sound rather than to visual stimuli. The animal made a number of attempts to jump over a one-meter fence and once succeeded in doing so. This represents a response considerably more complex than simple reflex movements to external stimuli. After the removal of the cerebral cortices the fur-cleaning activities of this cat were awkward and uncoordinated; the movements of the tongue and lips were excessive and the accompanying head movements were inappropriate. With practice the animal relearned

to direct her head and tongue movements more effectively and eventually she was able to perform the fur-cleaning responses quite accurately. Although she continued occasionally to make errors, such as licking the floor or the walls of the enclosure, there was a decided improvement in the accuracy and effectiveness of her reactions.

Bard (1) reports an interesting case of learned behavior in one of his decorticate cats. The animal was allowed the freedom of a large laboratory room and soon was observed following the experimenter about the room. On some occasions the cat would follow the experimenter out into a corridor, along it for ten or twenty yards, and back again into the room. The adequate stimulus was thought to be auditory as the cat's responses to auditory stimuli were particularly brisk on the days the following-behavior was obtained. Bard's investigations on the nervous mechanisms of emotional responses, although not specifically concerned with learning situations, contribute information on the manner in which subcortical nuclei may function. He has demonstrated that particular nuclear regions in the diencephalon are necessary for certain types of emotional responses. Evidently these nuclear regions have become specialized to perform certain functions and their removal results in a complete loss of these functions.

It is apparent from these experiments on decorticate animals that simple learned responses can be performed by higher mammalian forms in the complete absence of the cerebral cortex. The responses to visual and auditory stimuli are not merely reflex in nature but manifest an aspect of recognition and discrimination which indicates the utilization of past experience. The complex coordinations studied showed changes with practice; there was improvement in accuracy and effectiveness of response which is a fundamental characteristic of learned behavior.

Few investigations of learning have been made in which the subcortical centers were the specific subject of study. The work of Freeman and Papez (7) on the functions of the superior colliculi in brightness discrimination represents an

attempt to study these centers when the overlying cerebral cortex, the visual projection fibers from the lateral geniculate bodies, and the spino-thalamic and the lemniscal systems are not disturbed. These workers used the Yerkes discrimination box and tested the effect of subcortical lesions on both learning and relearning. The results indicate a general tendency for the larger lesions to produce more severe disturbances. However, no clear-cut conclusions on the special significance of any group of nuclei are possible from their findings. The reason for this was their inability to produce well isolated lesions within specially defined areas. Their method was to insert a probe underneath the occipital lobe into the right superior colliculus and then to destroy the two superior colliculi by rotating the probe. The chief object of the operation was to keep the destruction within the superior colliculi and not to disturb the overlying cortex or the adjacent subcortical nuclei. In no instance was this realized. In the two parts of the investigation 20 rats were subjected to subcortical operations. In no animal was the lesion strictly confined to the superior colliculi and in only one rat was the lesion confined to the four corpora quadrigemina. In the remaining animals from two to six other nuclei were affected in addition to the superior colliculi under study. Some impairment of the occipital cortex was found in all of the cases. It is obvious that such complicating of the anatomical picture makes impossible a correct interpretation of the behavior details.

In his experiments on pattern vision Lashley (22) found that a lesion in the superior colliculi of rat 47, produced incidentally in an operation upon the striate areas, caused very severe changes in the animal's behavior. The rat was completely disoriented on the platform of the apparatus and showed no evidence of vision for the position of objects. A special attempt was made to test if this unusual defect was the result of the involvement of subcortical nuclei. Rats 48, 49 and 50 were prepared with extensive lesions in the superior colliculi and small destructions in the adjacent subcortical nuclei and the cerebral cortex. All three of these animals were completely disoriented on the apparatus and gave no

evidence of ability to respond to the position of objects. No. 51 with lesions in the optic radiations, the lateral geniculate bodies, and the radiations of the optic nerve, likewise was completely disoriented.

Additional information upon the functions of the superior colliculi in the brightness discrimination habit and in reactions to black and white cards and simple patterned stimuli was obtained by Layman[2] (**29**). He trained animals upon the Yerkes brightness box and Lashley's jumping apparatus. The incisions were made through two trephine holes near the midline of the occipital lobes. A fine knife was passed through each of the trephine openings to the superior colliculus of the opposite side, care being taken to insert the knife between the hemispheres in the longitudinal fissure. Three of the 15 operated rats showed no apparent destruction in the midbrain nuclei. The lesions of the remaining 12 animals, except rat 4, involved varying amounts of destruction in adjacent subcortical and cortical tissue. Bilaterally similar subcortical lesions were produced in only three rats, nos. 4, 7 and 11, the injury in rat 4 being confined to the superior colliculi; the injuries in rats 7 and 11 involving considerable destruction in other subcortical nuclei. Rat no. 12, with almost complete destruction of both cortical and subcortical visual centers, showed no tendency to learn and apparently was completely blind.

Not enough cases with well defined and bilaterally similar lesions are provided to determine the exact functional contribution of the superior colliculi. However, Layman has provided the records of a normal group of animals for comparative purposes and some interesting differences can be noted between the performance of the normal rats and those having lesions in various midbrain nuclei. The average learning scores for the normal and operated animals, trained under similar conditions, are as follows:

[2] The author is indebted to Dr. I. Krechevsky, at the University of Chicago, for furnishing tracings and descriptions of the lesions produced in the animals studied by Mr. Layman. The author was unable to procure Mr. Layman's thesis at the time of the writing of the present paper.

TABLE I

	Yerkes Box		Black vs. White		Pattern Vision	
	Trials	Errors	Trials	Errors	Trials	Errors
Normal.....	146.0 (5)[a]	41.0 (5)	20.0 (5)	3.6 (5)	60.0 (5)	20.8 (5)
Operated.....	154.3 (7)	49.1 (7)	88.0 (5)	23.8 (5)	80.0 (4)	23.8 (4)

[a] The number of cases determining each average is indicated in parentheses.

From these records it is apparent that, on the average, the operated rats are inferior to the normals in brightness discrimination and in reactions to black and white card stimuli. The differences in the scores for the brightness discrimination habit are small but are probably indicative of real differences as the average scores of these subcortical operates are greater than the average scores of any group of normals or cortical operates reported in previous studies upon this habit. The operated rats manifest a marked deficiency in reactions to the black and white cards, the scores of only two rats, nos. 4 and 8, falling within the range of scores of the normal animals. No. 4 had a small bilateral lesion in the superior colliculi; no. 8 had a large lesion concentrated principally in the right superior colliculus and the medial geniculate body. In pattern vision 3 of the 4 operated animals, nos. 1, 4 and 6, did as well as the normal rats. The scores for rat no. 3, with small lesions in the superior colliculi and medial geniculate bodies were 220 trials and 62 errors. Lashley's failure to obtain reactions to patterned stimuli from rats with injuries in the superior colliculi probably was due to the lesions involving greater amounts of destruction in the adjacent thalami and lateral geniculate bodies.

Although the limited number of cases in this study prevents making any conclusive statements, it would seem that lesions in the superior colliculi do not significantly affect reactions to simple patterned stimuli but reduce the ability to learn the brightness discrimination and black-white habits.

It will be pointed out further on in this paper that the first two habits very probably can be mediated wholly within the subcortex and that the superior colliculus is an essential part

of the nervous mechanism for each of these habits. Investigations of pattern vision have not contributed sufficient data on subcortical lesions to warrant making any conclusions at the present time. Each of these three direct attempts to investigate the functions of subcortical centers have demonstrated the need for a more refined surgical technique by which destruction can be accomplished in the deeper nuclei without impairing large amounts of the adjacent cortical and subcortical tissue.

In the majority of studies upon the functions of the cerebral cortex in learning, the picture of destruction has been complicated by the involvement of subcortical structures. Some knowledge of the significance of the latter may be gained from these studies but conclusions drawn from this kind of evidence are often limited by the fact that the cortical lesion is also contributing to any changes noted in the subsequent behavior. If we are interested in finding out if a task can be performed by an animal after the removal of a large amount of cortical tissue, then the duration of the training period for learning or relearning becomes an important item. This objective was not present in most of the cortical studies and the training of the animals was continued only to that point which indicated a reliable difference in performance between the normal and the operated animals. In many instances, then, we cannot conclude that the failure of operated animals to learn within the training period used is an index of their inability to learn with a greater amount of practice. If we are interested in gaining an exact knowledge of the functional importance of subcortical mechanisms in learning, another difficulty appears in studies upon the cerebral cortex. If, following an operation, the animal fails to retain the habit but successfully relearns it, the question arises as to whether another cortical mechanism is functioning vicariously or whether the subcortex is performing the activity without cortical assistance. Although this question has arisen in most of the studies on the cortex, it has been experimentally investigated in only one or two instances.

In reviewing the large number of data on cortical functions,

for any information which they may contribute on the significance of subcortical centers in learning, each type of problem will be considered separately. The most thoroughly studied problem is that of brightness discrimination (**15, 16, 17, 18, 19, 20, 23**) in which the following facts have been experimentally demonstrated. (1) After normal rats have learned to differentiate between light and darkness the removal of the striate areas completely disrupts the habit. (2) The relearning of the habit, after the removal of the striate areas, involves about the same number of trials and errors as are required for the original learning. (3) The removal of the striate regions before training does not affect the animal's ability to learn. (4) After the habit has been established, the removal of any third of the cortex other than the striate areas has no affect upon the retention. (5) When rats without the occipital third of the cortex have learned the habit, the removal of any other third of the cortex does not interfere with their ability to discriminate light and darkness.

Following his first experiments, in which evidence was obtained for establishing the first four facts (**15, 16, 17**), Lashley was inclined to believe that some other part of the cortex was functioning vicariously for the striate areas. A subsequent investigation (**18**) disproved this hypothesis. The cortex was then said to have a diffuse function, and all parts were declared to be equipotential for the habit. This point of view was reaffirmed in 1926 (**19**, p. 36) and again in 1929 (**20**, p. 127 and p. 140) despite the fact that both of these investigations had shown that cortical mass played a minor role in brightness discrimination and that the destruction of certain thalamic nuclei very greatly retarded the habit. Herrick (**10**, chaps. IX and XI) had previously pointed out the plausibility of the habit being mediated wholly at subcortical levels. This hypothesis was rejected by Lashley on the grounds that it lacked experimental support (**18**) but in more recent papers (**21, 22, 26**) he has accepted it as the correct interpretation.

The theory that any part of the cortex may mediate brightness discrimination demands a rather diffuse represen-

tation of the retina upon the cortex. Each of the cytoarchitectural fields must be served by projection fibers from the subcortical visual nuclei. Recently Lashley's very thorough anatomical analyses (**27, 28**) of the projection of the retina upon the primary optic centers and upon the cerebral cortex in the rat have tended to cast doubt upon this conception. Destruction of the entire striate areas resulted in a complete degeneration of the lateral geniculate bodies and no apparent degeneration in any other subcortical nuclei. Lesions in other parts of the cortex caused no degeneration in the lateral geniculates. No evidence was obtained for a diffuse cortical representation of the retina by way of any other subcortical nuclei. These findings discredit the hypothesis of a generalized vicarious function by other parts of the cortex in the absence of the striate areas.

That the thalamus is one of the important subcortical nuclei in brightness discrimination was demonstrated by Lashley in 1926 (**19**). The cortical lesion produced in rat no. 49 was a small one, being no greater than the lesions of many animals who learned the habit in normal time. In addition this rat had a severe lesion in the thalamus. His learning scores in trials and errors were almost double those made by the slowest operated rat with which he was trained. Different amounts of destruction in the thalamus occurred in rats 99, 100, 101 and 102. Their relearning scores averaged 152 trials and 54 errors. The relearning scores for the other rats with comparable cortical destruction but without subcortical lesions were 44.6 trials and 13.7 errors. The magnitude of the difference between these groups, with and without destruction in the deeper nuclei, supports the contention that lesions in the subcortical visual nuclei disturb the habit to a greater degree than lesions in the visual cortex.

It would appear from the experimental studies thus far made that the habit of brightness discrimination may be mediated by the subcortical visual nuclei; that when the striate areas are present they are incorporated into the habit, but in their absence the subcortex is sufficient.

Experiments with the inclined plane problem box[4] (14, 20) seem to point to the frontal lobes as the important cortical areas for learning. The number of animals trained on this problem is small and the following statements summarizing the experimental findings are not to be considered as conclusively demonstrated. (1) After normal rats have learned the problem the entire removal of the frontal lobes results in a complete loss of the habit. (2) The relearning of the problem, following destruction of the frontal poles, is accomplished with the same trials and errors as are required for the initial learning. (3) The removal of the frontal lobes preceding training does not reduce the animal's ability to learn the habit. (4) The destruction of the temporal lobes following learning has no effect upon the retention of the problem. There is some evidence from the later experiments (20) that destruction in the posterior poles, Fortuyn's areas *w* and *p*, retards the learning of the habit. No experiments have been reported in which the vicarious function of another area of the cortex has been tested.

It would appear from these facts that when the frontal lobes are present they are incorporated into the habit but in their absence other neural mechanisms are sufficient. Whether these other structures are wholly subcortical, or whether other cortical areas are functioning vicariously, cannot be determined from the data now available. That certain motor nuclei of the corpus striatum are important for the habit is clearly demonstrated in the study by Lashley and Franz (14). Rats 27, 30 and 32, with severe bilateral lesions to the corpus striatum, failed to relearn the problem. Nos. 29 and 33, in which one corpus striatum and the opposite cerebral peduncle were disturbed, also failed the relearning test. Nos. 25 and 26 with unilateral lesions, executed a few correct trials but died before they had completely relearned. No. 23 with the caudal parts of both corpora striata affected,

[4] The inclined plane problem box is not to be confused with the inclined plane discrimination box. In the former the rat presses down a treadle located on the top of a cage, the movement opening the cage door and enabling the rat to reach food. In the latter the rat discriminates the difference in incline between two alleys, one of which leads to food.

and nos. 18 and 19 with small lesions in the lateral and dorsal aspects, respectively, of one striate body, showed some retention of the problem. Although the number of cases prevents making any definite conclusions the evidence seems to point to subcortical nuclei, and particularly the anterior nuclei of the corpora striatum, as a necessary mechanism for the execution of the inclined plane problem box. Whether or not the proper functioning of this mechanism requires a minimal amount of functional cortex is not determinable at the present time.

The results from studies on the double platform problem box (**11, 15**) are similar in some respects to those of the inclined plane. The following statements summarize the experimental findings. (1) The destruction of the frontal lobes in trained animals completely disrupts the habit. (2) Following the destruction of the frontal areas the number of trials and errors involved in relearning the habit is about the same as the number required for the original learning. (3) The extirpation of any cortical fields other than the frontal lobes has no effect upon the retention of the habit. (4) The removal of the anterior half of the cortex before training does not reduce the rat's ability to learn. (5) The rate of the initial formation of the habit is not influenced by lesions in other cytoarchitectural fields. No experiment has been directed toward discovering if a definite cortical area functions vicariously after the destruction of the frontal lobes.

In Lashley's study of this problem the removal of various parts of the cortex facilitated learning, the operated rats requiring 63.6 trials less than the normal rats, a difference of 44.6 per cent. This superiority was attributed to the difference in vigor of the two groups. It was claimed that the paretic animals in the operated group were more apt to trip the latches than the more active normal rats who tended to jump over them. A careful analysis of the data throws some doubt upon this interpretation. Paresis results when extensive lesions to the stimulable cortex is accompanied with unilateral lesions to the corpus striatum. Only 6 of the 19 operated animals could be classed as paretics. The average

number of errors made in learning for the normal animals was 142.6 ± 9.2, and for the paretics 62.6 ± 6.2. The non-paretic operates (excluding no. 17) made an average of 87.1 ± 9.6 errors. The difference between the normals and the non-paretic operates is 55.5 ± 13.3, the probable error ratio being 4.2. Only one operated rat made a score greater than the mean of the normals. This was no. 17 who was ill throughout the experiment and who failed to learn the problem in 250 trials. Obviously, paresis *per se* was not the sole cause for the superiority of the operated rats.

It is questionable whether the difference in vigor could account for any of the observed difference in learning between the operated and normal animals. Fortunately daily records were taken of the activity of some of the rats. A close examination of table 1 (**15**), p. 71 reveals no striking difference in activity of the two groups. The operated animals averaged 5.60 hours of activity per day, whereas the normal animals averaged 5.58 hours. As there was no correspondence between the general activity of the rats and their rates of learning, the superiority of the operated animals cannot be ascribed to their lack of vigor. No other experiment, in which the double platform box was used, offers evidence which might disclose a clue to the correct interpretation. It seems certain that the problem can be readily learned in the absence of any part of the cortex but the relative importance of the different subcortical nuclei is not revealed. That the corpus striatum is involved has already been pointed out. In the absence of the stimulable cortex this motor nucleus carried out the function successfully, which fact suggests the hypothesis that the habit of the double platform box can be executed by nervous mechanisms lying wholly at subcortical levels.

The findings with reference to the neurological structures functioning in maze learning are not the same for the very simple maze used by Franz and Lashley (**6, 14**) as for more complex mazes (**20, 25**). The experimental facts for the simple one cul-de-sac maze of these investigators are as follows. (1) Normal animals retain the simple maze habit

after the removal of the anterior third of the cortex. (2) The habit is retained after the removal of any third of the cortex other than the frontal lobes. There is some evidence that the removal of the anterior third of the cortex does not affect the rat's learning ability but the small number of cases available prevents the making of a conclusive statement. The habit of this simple maze is apparently not dependent upon any particular cortical region. Whether it can be learned in the absence of all the cortex has not been proved. However, to assume the equipotentiality of the various cytoarchitectural fields for the habit would be gratuitous without some evidence that cortical tissue is necessary for learning the problem. A few instances of lesions in the corpus striatum point to this structure as one of the important neural mechanisms. Rats with one corpus striatum injured were retarded, although they eventually learned the maze. Destruction to both corpora striata seemed to completely prevent the formation of the habit. These facts support the contention that the essential nervous pathways for this simple maze habit lie in the anterior nuclei of the subcortex.

It has been definitely proved that the learning of mazes of greater difficulty than the one used by Franz and Lashley [5] is dependent upon the functional integrity of the cerebral cortex (**20, 25**). The amount of the retardation in learning or the amount of the loss in retention is proportional to the mass of cortex destroyed. The effect seems to be the same regardless of which of the cytoarchitectural fields is removed. The conclusion made in most investigations in which attention is given to the incidental destruction occurring in subcortical nuclei is that specific types of subcortical lesions do not differentially affect the learning or retention of complex mazes. A number of reasons for not accepting this interpretation may be briefly stated: (1) the number of cases with significant subcortical lesions in any one experiment is usually small; (2) the subcortical lesions are seldom bilaterally similar; (3) the lesions usually involve more than one of the major

[5] In 1929 Lashley (**20**) used a one cul-de-sac maze somewhat more difficult than the one employed in the study by Franz and Lashley. Cortical injuries resulted in retardation in both learning and relearning in this maze.

subcortical nuclei; (4) in cases where similar subcortical lesions are produced, the cortical destruction is found to vary in locus and amount; (5) due to the large individual differences in learning and retentive capacity found in rats the practice of determining the effect of a given subcortical lesion in one animal by matching it with an animal of equal ability but with a different subcortical lesion is not justified; (6) because of the temporal limits of many of the experiments the training may have been terminated before any differential effects could have been manifest.

Two very complete studies on the influence of cortical lesions on the learning of the maze were made by Lashley and by Lashley and Wiley (**20, 25**). Neither of these investigations contribute sufficient data concerning subcortical functions to warrant an analysis. Conclusive statements on the effects of subcortical lesions on the complex maze habit cannot be made until a greater amount of systematic investigation of the functions of the deeper nuclei has been accomplished.

A number of experiments (**21**) have been made on the influence of cortical lesions on the differential reaction to two lights when the intensity difference is well above the liminal value and on the threshold for differences in brightness between two lights. The following statements summarize the experimental facts. (1) When the habit of discriminating supraliminal differences in intensity of two lights is established in normal animals the subsequent complete destruction of the striate areas abolishes the habit. (2) After loss of the habit through occipital lesion, the discrimination can be reestablished with about the same amount of practice as is required by untrained normal animals. (3) Lesions within other cytoarchitectural fields of the cortex do not disturb the retention of the habit. (4) The rate of the initial formation of the habit of discriminating liminal differences in the intensity of two lights (difference threshold) is slightly retarded by the removal of the visual cortex. (5) When normal rats whose difference thresholds for brightness have been determined, are subjected to lesions in the occipital cortex, the

postoperative average threshold value is increased. (6) In animals whose difference thresholds are determined after the removal of the visual cortex, the average threshold value is higher than for normal animals.

In the discrimination of supraliminal differences in intensity of two lights the cortex has a facilitating effect upon the retention of the habit, an effect similar to the one which is present in the brightness discrimination habit in which light and darkness are used as stimuli. This facilitation seems to be somewhat greater in the case of the two lights as animals with the striate areas removed consume a greater amount of practice in the original learning of the habit than is required by normal animals. However, it should be pointed out that although the average scores in trials and errors of the operated group were considerably greater than for the normal, half of the operated group (8 in 15) performed as well or better than the average of the normal group. The striate areas are not essential for the habit, although if they are present they are incorporated into the neurological pattern. It appears that other cytoarchitectural fields are not involved in the discrimination but experiments have not been conducted to determine whether another cortical area functions vicariously when the striate areas are removed. Lashley does not describe the amount of subcortical tissue destroyed although the deeper nuclei were invaded in many of the animals subjected to occipital lesions. The subcortical destruction was apparently too small to cause any detectable differential effects upon the performance of the animals.

The results on the threshold for differences in brightness also disclose the presence of cortical facilitation. In a group of 17 normal rats 10 of them mastered the problem when the ratio of the two lights was 2 : 1; only 2 out of 15 operated rats attained this threshold. Although this fact is suggestive of cortical facilitation it also indicates that operated rats with the striate areas removed may have apparently normal thresholds. The training period for each threshold test usually consisted of no more than 100 trials and very probably with further training more of the operated rats would have

attained the 2 : 1 threshold. Among the rats whose thresholds were tested both before and after cortical destruction, 7 out of the 17 performed as well or better in the postoperative test than they had performed previous to the operation.

It is evident from the foregoing experimental results that the ability to discriminate supraliminal differences between the intensities of two lights and the threshold for differences in brightness are primarily dependent upon subcortical structures. In the absence of the striate areas subcortical nuclei are probably sufficient for carrying out the essential responses, but when the striate areas are integrated into the nervous pattern the responses are executed more effectively.

The factual evidence from investigations (**22**, **24**) on the influence of cortical lesions on the vision for objects and patterned stimuli is exceedingly difficult to interpret in terms of subcortical functions. A number of reasons for this difficulty may be suggested. (1) The number of animals with comparable subcortical lesions is small. (2) The training periods for the various tests were too short, never averaging more than 117 trials. (3) The unreliability of the apparatus makes the interpretations of certain borderline cases very difficult. (4) The fact that the range of variation for normal rats on the apparatus is not accurately known increases the difficulty of evaluating small amounts of deficiency or retardation. The following statements on the effects of cortical lesions on vision for objects and patterns are suggested by the experimental findings. (1) The destruction of large amounts of tissue in any of the cortical fields, including the striate areas, does not affect the animal's orientation on the apparatus or his ability to react to visual objects. (2) The interruption of the optic radiations at their point of emergence from the internal capsule reduces the rat's capacity to react to visual objects. (3) The complete destruction of the striate areas decreases the accuracy of response in tests of pattern vision. (4) The ability to differentiate patterned stimuli is not affected by lesions in cytoarchitectural fields other than the striate areas.

In his investigation of 1931 (**22**, p. 470) Lashley states that the interruption of the optic radiations "abolishes all capacity to react to visual objects." This is based on the fact that the area common to the lesions of rats 18, 19, 20 and 21 lies directly over the point at which the visual projection fibers enter and leave the internal capsule. These rats were completely disoriented on the apparatus and could not be made to respond to visual objects. However, in the light of other facts it is questionable whether ability to respond to visual objects is always completely abolished. Nos. 10, 23, 30, 31 and 32 had cortical lesions directly over the internal capsule. All of these animals were visually oriented on the apparatus. The responses of no. 10 in all the tests were well within the range of variation for normal rats. No. 31 learned to differentiate squares of different areas. Nos. 23 and 30 passed the tests for 2-cm. striæ and no. 30 showed transposition to 1-cm. striæ. In nos. 28, 29, 30, 31 and 32 the cortical destruction involved 98 per cent or more of the striate areas. Everyone of these rats was oriented on the apparatus, and everyone but no. 32 responded to visual objects. It is difficult to conceive of the interruption of the projection fibers which serve a given area causing a more profound effect than the destruction of that area. These facts are not easily reconciled with Lashley's statement. At least with some animals, it appears that severing all of the visual projection fibers or completely extirpating the striate areas does not abolish all capacity to respond to visual objects. When these facts are considered in conjunction with the recent findings that the retina is projected upon the cortex within the circumscribed striate areas, the possibility of subcortical nuclei being sufficient for this type of visual response is strengthened. At least until further experimental evidence is forthcoming the subcortex can be considered to contain the necessary and sufficient nervous mechanisms for responding to visual objects.

The facilitating effect of the striate areas in pattern vision offers further difficulties of interpretation. Rats 42, 43 and 44, with over half of the field destroyed made scores well

within the normal range in all pattern vision tests. Nos. 17, 30 and 38, with lesions involving 57 per cent, 100 per cent and 63 per cent, respectively, of area *w*, reacted correctly to 2-cm. striæ, no. 30 showing direct transposition to 1-cm. striæ, although all three failed the tests for triangles. Rats 23, 25, 26 and 27, with small regions of area *w* invaded, failed to pass any of the tests of pattern vision. It appears that there is no relationship between the retardation in the tests and the amount of area *w* destroyed, and that some animals with most of this area removed can be trained to correctly differentiate patterned stimuli.

The limitations of the experimental evidence on pattern vision prohibits the making of any final pronouncement on the exact functional significance of subcortical nuclei. The superior colliculi and lateral geniculate bodies have been shown to be essential for the habit. The answer to the question as to whether responses to simple patterns of stimuli can be carried on wholly at subcortical levels must await further experimental work.

Recently Swan (39) has reported an investigation of the olfactory discriminatory capacity in rats. The influence of lesions in various regions of the neopallium and the archipallium on the relearning of a simple discrimination habit to two odors was measured. The experimental results follow. (1) Excision of 60 per cent of any of the major cytoarchitectural fields of the neopallium had no effect on the retention of the habit. (2) The destruction of the various major complexes of the archipallium, including the hippocampal complex, pyriform lobe, septum and amygdaloid nucleus resulted in no loss in retention. The olfactory tubercle and the precallosal hippocampus were not destroyed. (3) The interruption of the lateral and medial olfactory stria disturbed the retention but the animal relearned the habit. (4) The sectioning of the anterior portion of the anterior commissure, together with injuries to the lateral and medial stria, resulted in complete and permanent loss of the ability to discriminate.

Because of the primitive nature of the olfactory response

it is not surprising that the removal of the cytoarchitectural fields of the neocortex produces no disturbing effect. The absence of specialization of the individual nuclear regions of the archipallium is further evidence of the lack of differential development in the rat brain, a point which has been emphasized by Herrick (**10**, chaps. IX and XI).

Following the lead of Lashley, Swan has attempted to explain the experimental results on the basis of equipotentiality, stating that "the subordinate parts of the olfactory structures are completely equipotential" for the habit. However, the results obtained by Lashley with mazes are quite opposed to those obtained by Swan for the olfactory discrimination habit. Lashley (**20**, **25**) has shown that cortical destruction in any of the cytoarchitectural fields seems to cause the same sort of retardation in relearning, the relationship between destruction and retardation being of a quantitative and not a spatial nature. On the other hand, destruction in any of the cortical areas of the neocortex or destruction of any of the major nuclear groups of the archipallium (with the exception of the olfactory tubercle and the precallosal hippocampus which were not investigated) produces no loss in retention of the olfactory habit. Because of the anatomical relationships involved the conclusion is obvious that the neocortex is not necessary for this type of discrimination but there is also an indication that the various archipallial structures actually destroyed may not be of especial importance for the habit. Before making the assumption that any one of a number of regions are equipotential for a given function, it should first be proved that these regions are at all necessary for the function. In presenting his argument for the assumption of equipotentiality of the subordinate parts Swan appeals to the traditional concept that learning takes place in the higher centers—meaning cortical centers, a belief which has been proved not to be true for many simple types of responses. The available evidence does not reveal the essential nervous mechanism for the olfactory discrimination habit although it strongly suggests some subcortical mechanism such as the olfactory tubercle. This nucleus receives

fibers from the olfactory bulb through the medial stria and in turn contributes to the medial forebrain bundle by which it communicates with the important motor centers of the hypothalamic region. It is also afferently and efferently related with most of the higher olfactory complexes. However, in the light of our present knowledge, it would be premature to localize the neural mechanism for the olfactory discrimination habit in the olfactory tubercle.

A number of experiments on the nervous basis of reactions to sound stimuli have been reported. For the purposes of this paper only those involving some type of learning situation need to be mentioned. Kalischer (13) worked with dogs, teaching them to accept food when a certain noise or tone was given and to refuse food when some other noise or tone was presented. After the removal of both temporal lobes the dogs lost their ability to discriminate noises but were still able to discriminate tones. Accordingly, Kalischer attributed the reactions to tones to subcortical centers and the reactions to noises to the temporal lobes. In a similar experiment Rothmann (37) found that bilateral removal of the auditory cortex, as outlined by Munk, produced complete and permanent deafness for all sounds. Swift (40) taught dogs to react to a food tone c^1 and to inhibit the reaction to a non-food tone e^{11}. He found that removal of the temporal lobes did not abolish the discriminatory response. Pavlov (33), through the conditioned reflex method, has shown that destruction of the temporal lobes disturbs conditioned auditory reactions, which can be reestablished only in the presence of other cortical tissue. A number of general auditory motor reactions such as pricking up the ears and lifting the head are ascribed to subcortical nuclei. Pavlov (33, p. 330) claims that no conditioned responses can be set up in the total absence of the cerebral cortex.

Recently a very well controlled investigation on the influence of cortical lesions on auditory discrimination has been reported by Wiley (41). He investigated the effect of the removal of area *p*, the supposed auditory cortex in the rat, upon the retention of a habit involving a response away from

the source of a sounding buzzer. The following statements summarize his findings. (1) The destruction of the posterolateral part of the cerebral cortex in rats which have previously learned the auditory discrimination habit results in a significant, though not a total loss of the habit. (2) After suffering a loss from the removal of area *p*, the animal relearns the habit in fewer trials and with fewer errors than is required by normal animals. (3) Destruction in other cortical fields apparently does not disturb the ability to discriminate. Although greater loss results from the removal of area *j* than from the removal of either area *w* or *f*, it is very probably due to the fact that the operations in area *j* invaded the projection fibers and cortical tissue of area *p*. The difference between the number of trials and errors required by normal animals in learning the discrimination and the trials and errors required by animals with lesions to area *p* for relearning the habit is statistically significant.

In discussing the results Wiley presents two possible explanations for his findings: (1) that, upon the removal of area *p* some other cortical area functions vicariously, or (2) that the relearning of the habit is accomplished by subcortical centers. The first of these explanations is supported by Pavlov's researches on conditioned responses in which it has been impossible to establish conditioned reactions in decorticate animals. However, this claim is to be seriously questioned in the light of the work of Poltyrew and Zeliony (**34, 35**) in obtaining conditioned responses to sound and light stimuli in decorticate dogs, and the finding of simple learned responses in decorticate cats by Bard (1) and by Schaltenbrand and Cobb (**38**). No experiment has been reported in which the subcortical nuclei involved in auditory reactions have been studied. Wiley's experiment shows plainly that area *p*, when present, is integrated into the nervous pattern of the auditory discrimination habit. Whether subcortical mechanisms are adequate to carry out the discrimination independently of the cerebral cortex cannot be determined without further experimental work.

A number of studies have been made of the nervous

mechanisms functioning in highly complex problems involving what might be termed reasoning ability. The information concerning subcortical functions in such experiments is decidedly meager. In the reasoning problem of Maier (**31, 32**) the removal of cortical tissue in either the anterior or posterior poles resulted in failure to solve the tests. When the amount of cortical destruction exceeded 18 per cent in the anterior region or 22.8 per cent in the posterior region the percentage of failures greatly increased, indicating what seemed to be a critical amount of cortical tissue in each of the regions explored. In the experiment on the anterior cortex the caudate nucleus was injured in 13 rats, 9 of whom failed the tests. All of those failing had lesions of 18 per cent or more in the frontal lobes. Five rats with injuries to the hippocampus failed the tests but each of them had 18 per cent or more destruction in the anterior cortex. In the experiment upon the posterior areas of the brain 35 rats suffered lesions to the hippocampus, 17 of whom failed the tests. Only two of these 17 had lesions smaller than the critical area of 22.8 per cent, whereas 18 rats with lesions in the hippocampus successfully passed the tests. From these facts it would appear that the hippocampus and caudate nucleus are not particularly important for the reasoning tests. The significance of other subcortical nuclei for this problem cannot be determined at the present time.

Loucks (**30**) has shown that destruction in the frontal lobes may affect both the learning and the relearning of the double alternation problem. No part of the frontal region seems to be more important than any other part. However, the integrity of the frontal lobes is not essential for either the learning or the retention of the problem, as over 50 per cent of the animals made delayed responses after the operation. No description is given of subcortical lesions.

From the foregoing discussion of the significance of subcortical lesions incidentally produced in studies primarily concerned with cortical functions, certain tentative conclusions may be formulated. (1) The following habits can be innervated by the nuclear regions of the subcortex entirely

independently of any cortical areas: brightness discrimination, inclined plane problem box, double platform box, simple maze, olfactory discrimination and auditory discrimination. (2) There is some experimental evidence that the corpora striata are the essential centers for the habits of the inclined plane problem box and the simple maze, and that the optic colliculi are essential for brightness discrimination. (3) With prolonged training, rats, in whom the striate areas have been removed, can be shown to perform as effectively as normal animals in the following situations: the recognition of visual objects, the discrimination of two lights where the difference in intensity is well above the limen, and the threshold for differences in brightness. However, the learning of the responses essential to these tasks is decidedly facilitated by the striate areas. (4) The learning of complex mazes, and successful performance on reasoning tests seem to demand functional cortex for their execution. The training periods used in the experiments dealing with these problems have not been long enough to justify a conclusion that animals handicapped with large cortical lesions could never master the problems but the available evidence strongly points in this direction.

It is obvious from the foregoing detailed review of the experimental findings concerning the subcortex that much further work must be done before conclusive statements can be made concerning the functional significance of the subcortical mechanisms in learning. Without an exception every experiment which has contributed to our understanding of the deeper nuclei, has involved a considerable amount of cortical destruction. It is then impossible to accurately separate the retardation incident to the removal of cortical tissue from that resulting from subcortical lesions. Direct attack upon the deeper nuclei has been retarded because of the failure of investigators to utilize techniques of destruction which do not involve gross injury to the cortex. By means of high frequency currents (**2**) it is possible to destroy the deeper nuclei with a minimal destruction of the overlying cortex. This operative technique makes it possible to study

these nuclei when they are functioning under the normal restraining influence of the cortex.

Control over the locus of the destruction offers another difficult problem in studies on the subcortex. Reference has already been made to the limitations of previous investigations in which the subcortical lesions involved so many different nuclear groups as to make it impossible to determine the functions of any one nuclear region. In the high frequency current technique the destruction is held to the tissue immediately adjacent to the tip of an insulated electrode. The amount of the destruction is controlled by the duration and the voltage of the current and can be accurately varied within a rather wide range. Control over the locus of the destruction is achieved by controlling the position of the pointed electrode within the brain. This is accomplished by means of a combination head-holder and goniometer-manipulator (5). The positions of the deeper nuclear regions are determined by referencing them to certain external land-marks of the cranium. These landmarks also serve as reference points for the adjustments of the electrode manipulator. It is then possible, knowing the position of a given center in terms of these landmarks, so to adjust the manipulator as to bring the point of the electrode to a position within this center.

Although this method of operation reduces the variations in the loci of subcortical lesions, certain limitations in the rat, such as the small size of the individual nuclear regions and the individual variations in cranial topography, make it very difficult to produce comparable lesions in different animals. The experimental groups, then, of necessity, must be small and it becomes extremely important to use highly reliable problems in the learning situations to be studied.

The apparatus utilized in the investigations reviewed in this paper have not been proved sufficiently reliable to be used in studying differences in individual performance. In fact, reliability has not been considered an important item in most of these studies. The highest reliability reported by Lashley (20) was a coefficient of .79, which was computed

for his eight cul-de-sac maze.[6] No coefficients are given for the problem boxes, but other investigators have shown the reliability of these problems to be exceedingly low; .09 and .50 for the inclined plane problem box (9) and .15 to .52 for the sawdust problem box (12). Loucks (30) reports reliability coefficients from .50 to .70 for his double alternation problem. The reliability coefficients by the repeat method for the reasoning test (32), using the rank difference method, are .07, .39 and 46.[7] None of these problems are reliable enough to be used for indicating individual differences although some of them can be utilized in studies of group differences.

In beginning a systematic study of the subcortical mechanisms in learning, an effort was made to obtain a number of highly reliable problems which could be mastered within a reasonable length of time by operated animals. The following five problems[8] were selected: (1) an eighteen unit multiple-T maze, (2) a four unit brightness discrimination box, (3) a six unit inclined plane discrimination box (3), (4) a twelve unit olfactory discrimination runway, and (5) a twelve unit apparatus for testing pattern vision (4). The reliabilities of these problems computed from odd-even trial scores and corrected by the Spearman-Brown formula are as follows:

TABLE II

RELIABILITY COEFFICIENTS

Problem	Controls		Operates	
	r	n	r	n
Maze	.995	23	.995	18
Brightness discrimination	.802	23	.985	18
Inclined plane discrimination	.969	23	.974	15
Olfactory discrimination	.989	23	.989	15
Pattern vision	.997	22	.989	15

[6] Although no reliability coefficients are given by Lashley and Wiley in their article published in 1933 (25), the magnitude of the intermaze coefficients reported indicates that the longer mazes of this study are more reliable than the maze upon which the coefficient of .79 was computed.

[7] These coefficients were computed from the relative ranks of 14 normal animals in three repetitions of the test. The number of cases is too small to place much confidence in the coefficients.

[8] An apparatus was also constructed for measuring the rat's ability to discriminate sounds but was not included in this program because of the large number of trials required for learning. The reliability of this problem was .989.

From this table it is apparent that the problems are all highly reliable. In all but one case the coefficients indicate a reliability sufficiently high to be useful in studying individual differences.

In a number of experiments to be reported a group of operated rats with subcortical lesions, together with a group of operated-control rats, were trained on the problems described above. The order of training was the same as the order found in the table of coefficients, beginning with the maze and ending with pattern vision. In the brightness discrimination box the animals were required to go to the lighted alley. In the inclined plane discrimination box the true pathway was set at an angle of 20° with the horizontal, the false pathway at an angle of 10°. In the olfactory apparatus the rat was forced to go away from the odor of creosote and toward the odor of anise. In pattern vision black and white stripes, 1-cm. wide, were used. The rat was forced to go away from vertical stripes and toward stripes set at an angle of 30° from the horizontal.

With this set of problems it is hoped that reliable information may be gained on the functional significance of various subcortical mechanisms in learning. The effects of lesions in different nuclear regions of the subcortex upon the learning of the five different problems will be reported in subsequent papers.

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ORGANISMIC *vs.* MECHANISTIC LOGIC

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The Medieval Problem. Human thought, as far as Western civilization is concerned, emerged from the Dark Ages to a brilliant but temporary peak in the thirteenth century. It is interesting to note the main reason why this burst of insight characteristic of the Scholastics *was so short-lived* and that it succumbed so completely to the political, economic and religious revolutions that were to follow. *It lacked both the depth and vitality to solve the part-whole problem.* The human mind was not yet far enough away from the primitive vitalism and atomism of Greek thought. Indeed, medieval philosophy collapsed on the part-whole question. Did reality accrue to universals, the whole, or to particulars, the parts? This was a matter most vital to the church. If the nominalists were right, the church, as the symbol of a *real* universal kingdom, was a meaningless artifact, and its authority had no sanction. On the other hand if the realists were right, particulars, including human individuals had no real meaning or significance of their own, no part to play in the economy of the universe.

Compromises were ineffectual. Logic was still too absolutistic. Nevertheless, modern science is returning to Thomas Aquinas, Duns Scotus, and William of Occam, in many interesting particulars, especially in its emphasis on form, the principle of differentiation (individuation), the concepts of potential, minima, and infinity. But William of Occam, a nominalist, and therefore a radical, was the last of the disputants, so far as constructive thought is concerned, and scholarship sank into the depths, not to reach another height until 1650.

The Eighteenth Century. Again, interest in the part-whole question marks a revival of science and philosophy.

Mathematics was concerned with wholes. Interest centered about the general *form* of algebraic equations, even to the neglect of details, to the end that many of its proofs were of necessity refined at later dates. Geometry was also popular. On into the eighteenth century, principles of maxima and minima fascinated both mathematicians and physicists as demonstrations of a perfectly ordered Cosmic Plan laid down by the Will of the Creator (Leibnitz, Maupertuis and Euler). Newton was a teleologist, although he divorced his religious from his scientific beliefs more rigidly than many of his contemporaries. It is not true, as most 'orthodox' interpretations would have us believe, that Francis Bacon laid down induction as *the* scientific method. He did not assert that science should altogether do away with hypotheses and theories, or that experience is purely an empirical affair. He was opposed to Medievalism *because it refused to take its theories to nature and test them.* Bacon knew, as every master of scientific method has always known, *that either deduction or induction, overemphasized, handicaps the acquisition of knowledge.* He would be astonished, were he now living, to read in our textbooks such claims as these. "The Science of ———— is based entirely on facts. Facts speak for themselves with no reasoning behind them. Facts and reasoning are separate, and facts come first." Bacon would have deduction and induction advance together, neither ahead, neither last. He would give the mind free reign of imagination so long as it reasoned *with*, not in spite of, observation. Unfortunately, in its attitude, modern science, dating from 1840 to about 1915, *forgot all this.*

Thus, Bacon was interested, after all, in the relation of parts to wholes, of particular observations to deductive universal truths. So was Malpighi, who wanted to know what part a certain structure in the organism played in keeping the *whole* organism alive. Harvey, too, revealed his genius in restoring to modern science Aristotle's belief in epigenesis, a theory of embryonic growth based on an insight into the organism as *a unified whole.* We might go on. Descartes' main problem was to resolve the objective and material realm

of physical science and the subjective and immaterial realm of psychological science into a unity after he had sharply separated them by his original definitions.

From 1740 to 1800. The brilliant work of the seventeenth and early eighteenth centuries was to be forgotten, on the whole, for sixty years or more. Interest in the part-whole relation was to decline in favor of an interest solely in the parts. The main determining factor, no doubt, was the pressing problem of individual liberty. Nations were staggering under the tyrannies of absolute monarchs. Scientific theory as well as public opinion capitulated, completely, to this need. The socialistic ideals of Grotius and Campanella, dating from the mid-seventeenth century could be achieved only by concentrating, primarily, on the rights of individuals. Accordingly, we witness a period of mechanistic science, materialistic philosophy, empiric epistemology, sensationistic and association psychology, utilitarian ethics, contract theories of the state, an abandonment of rationalism for romanticism, idealism for hedonism, thought for feeling, and faith for skepticism. Preformation takes the place of epigenesis (on the whole); chemistry is based on substance; the universe is a fortuitous concourse of atoms; mathematics forsakes geometry and is interested almost exclusively in infinitesimals and probabilities. What an extraordinary universality of pattern. There are no wholes. There are only parts. It is each part for itself in physics, biology, philosophy, psychology, social science, and in public life. Therefore, revolutions, expansion, rugged individualism, war, and atomism; competitive forces are the source of evolution, under natural law. It was all needed. Nevertheless, constructive scholarship was in a relative decline all through this period.

Nineteenth Century. 1800 to 1840. Then came forty years of scintillating brilliance, reminiscent in pattern of 1650. Here the threads, dropped in 1740, were picked up again and carried to a striking climax. Geometry returned with a vigor that was tremendous. Steiner entitled his famous work on projective geometry, 'Systematische Entwicklung Abhängigkeit geométrischen Gestalten von einander.'

Problems of transformation, series, projection, form, expansion and unification dominated the mathematical mind; mass action, maximum work, field phenomena, pattern, the part *vs.* the whole (atom *vs.* the molecule), conservation (mass, matter, energy, areas, surfaces) dominated chemical and physical thought. Epigenesis, the organism-as-a-whole, teleology (rôle the part plays in the economy of the whole), form, homologous parts, archetypes, differentiation, parallelism between ontogeny and philogeny, unity of plan, all ruled in biological thought. Kant ushered in a new period of idealism and rationalism to reach its peak in Hegel's dialectics. Organismic (vitalistic) theories of the state supplanted the mechanistic contract theories; we witness an era of socialistic endeavor by practical-minded social theorists. Cooperation of parts within a whole took the place, in social scholarship, of competition and *laissez-faire*. Utilitarianism and hedonism were denounced. Here the germs of modern relativity and organismicism were born, only to remain dormant for almost a hundred years.

In psychology, the Scottish school of philosophers revolted against the associationism of the preceding mechanistic period—Th. Reid, D. Stuart, Th. Brown, and finally Sir William Hamilton. Brown's theory of suggestion was an effort to comprehend the original unity of mental life. He subordinated the conventional laws of association to emotional congruity and to the mental disposition as a whole. This, and Hamilton's redintegration theory, another effort to comprehend the primacy of wholes, raised psychology to the same pre-organismic peak that was reached by each of the other sciences. The movement was felt, also, in Germany and France. Herbart employed both the concepts of apperception and association in an effort to envisage a truly organic unity, in which plurality existed within that unity. It is not a discredit to the scientists of this period that they failed to solve their major problem. They tried. Less can be said of the return to mechanism that followed.

1840 to 1915. The history of science from around 1840 to 1915 is a conflict between two patterns of thought whose

logical incompatibilities were not resolved in the preceding cycles, the mechanistic and the organismic (which was vitalistic and mechanistic in fact but organismic in intent). Not even mathematics escaped, for its thought was saturated with mechanistic and absolutistic definitions. Here the climax came in the 70's and 80's when, before complex algebra could be freed from contradictions and restraints, revolutionary definitions of the infinite had to evolve, the commutative law abandoned as a universal principle, space redefined, a new theory of number advanced, and the infinitesimal forsaken. Typical, too, of this period, was the development of symbolic logic, with its interest in a generalized and unified system of mathematics, based upon rigorous definitions (Boole and de Morgan to Peano, Bertrand Russell and Whitehead). Outstanding was the brilliant discovery that mathematics was not the science of measurement or of *number* as such, but of logical form, order, pattern, matching and transformations. Measurement comes out of the fray an instrument only of *applied* mathematics; number is not a 'digit' but a system of classes (Cantor, Weierstrass, Dedekind, Hilbert, B. Russell).

Physics spent most of the century refining and expanding the discoveries of the preceding period, becoming more and more atomistic, interested in the calculus of probabilities, and the kinetic theory of gases. The atom was still a relatively solid, homogeneous corpuscle. Aside from the achievements of Claussius, Gibbs, and Maxwell there was little excitement until the century had almost closed. Sir Wm. R. Hamilton, R. Mayer, Faraday, Oersted, Lenz, Carnot, all belong to the preceding period. Thus physics approached the twentieth century in a very complacent mood. The law of gravity, Newton's laws of motion, the first and second laws of thermodynamics, the kinetic theory of gases, seemed to complete the picture. There was little more to be done. The universe had been reduced to mechanical law, there was nothing but the parts. There were two brillant men, however, whose complacency did not run so high—they were Ernst Mach, and that brilliant critic, Judge Stallo. Both died misunderstood and unappreciated. Why?

By 1840 scientific thought was descending into the second cyclic decline since 1650, and again because the culture pattern was shifting once more in face of the necessity (this time also an opportunity) for an intensive interest in parts. Populations were becoming congested, the franchise was still limited, the factory system awakened undreamed of possibilities for capitalistic empires. Before basic problems could be solved in the sciences, more detailed and accurate 'structural' knowledge was required. The mechanistic trend furnished an abundance of this knowledge, but also an abundance of false theory.

We descend, then, into a period of materialism, imperialism, individualism, war, and atomism. Again, it is just the parts. J. S. Mill returns to Adam Smith; Jeremy Bentham had revived the Utilitarianism of the eighteenth century; there is an anti-Hegelian reaction in philosophy, and another romantic movement—Schopenhauer and finally Nietzsche and von Hartmann. It is now the Will instead of the Idea. Rousseau is revived. We have Disraeli, and Bismarck. The United States went to war with Mexico and had a Civil War; Russia invaded Turkey; the Balkans revolted and Germany crowned its new Emperor at Versailles.

This same fever of *atomism*, *individualism* and *revolution* with its attendant philosophy of competition, hurl science and public life alike into bitter warfare. Chemistry went through 'the roaring forties' and even in the 90's was still quarrelling over whether substance or form, the mechanical atom or the energy system as a whole, was basic. Witness the long controversy over radicals, hinging on the problem whether substance or pattern was fundamental, which Gerhardt settled by means of a pattern concept. Note the schism between the *atomists* and the *stereochemists* with atomism carrying the day and Pasteur and Kekulé regarded with contempt. Recall how Ostwald was ridiculed because he was not an atomist.

In biology disputes were no less intense. Atomism received its first impulse in the cell theories of Schleiden and Schwann, carried on by Virchow, Vogt, and others, to reach

its depths of absurdity in Weismann's germ theory. The climax was reached in the middle of the century in the publication of Darwin's 'Origin of Species,' one of the most unfortunate books, perhaps, ever to have been written. However, Darwin cannot be blamed. He was a symptom, not so much a cause. But great theoretical biologists of the nineteenth century refused to capitulate either to atomism or to Darwinism. Among them were von Baer, Milne-Edwards, Johannes Müller, Claude Bernard, de Bary, Sachs, and Reichert.

Psychology had not awakened until the seventies, but even as it was coming upon the scene, it showed signs of the coming revolution. Restrained by atomistic modes of thought from which there was yet no escape, Wundt rested his final judgment upon creative synthesis, a direct recognition of wholes, but of necessity, vitalistic and mechanistic in the end.

In social science there was, down through the century, a prolonged stand against the mechanistic and individualistic trend in England, by a long line of vitalistic writers in Russia, Germany, and France, all of whom attempted organismic theories of society and the state. Even Spencer felt their influence and mixed organic analogies with atomistic individualism as only Spencer could.

The nineties should receive special mention. Across the gamut of the sciences, theory was hammering both against vitalism and 'machinism.' In psychology the Gestaltqualität movement, indeed the whole emphasis upon *act* and *intent*, the conation and self movements, the functionalisms of James and Ribot, were all symptoms of the swing of the whole culture pattern at the level of scientific scholarship *away from* atomism. But that they were solutions of the problem or even near solutions is by no means true.

In face of the great deal of experimental work from 1890 to 1910, which showed the inadequacy of the association theory, one marvels that psychologists as a whole were not more ready for Gestalt theory when it came. During this period probably no psychologist was willing to admit that he

was a pure associationist, and yet he refused to believe that the parts did not come first or that wholes were not derived. *Most everybody thought that the recognition of wholes and of an ordering process that began with the parts, solved the problem. But this is the logic of atomism and vitalism.*

James Ward in 1893 and 1894 recognized wholes and made them secondary, in terms of 'assimilation,' a mode of approach as mechanistic as Wundt's creative synthesis; Pillsbury, in 1897, concluded that association was subordinate to apperception, an indirect recognition of the primacy of wholes; in 1894 Howe could not find experimental evidence for 'mediate' association. Many other studies turned out the same way. T. L. Smith found her subjects, in 1896, learning material more quickly and accurately when they studied it as a whole. In 1900 Warner Fite was outspoken against psychic synthesis; A. E. Tanner in the same year *discovered images differentiating from homogeneous fields or masses;* and Höffding was reiterating his opposition to association. Many were the positions approximating a differentiation theory of sensory and imaginal experience. Binet, in 1903, was vigorous in his appeal to a 'Gestaltungskraft.' We might go on. But the list is long and tedious. Even in 1930 *Gestalttheorie* was under bitter fire, so necessarily drastic was the change in thought pattern if the problem was to be solved.

In biology we witness a growing interest in 'developmental mechanics' (Roux), a vigorous outburst, again, against the cell theory, and interest in cellular dynamics (Bütschli, Boveri). A functional biology was trying to be born. We have already spoken of the heroic struggles of Mach, Ostwald and Stallo in physical science. In social science, among numerous writers, McKechnie, Mackenzie and Kidd, gave us vivid descriptions of the social part-whole problem.

Twentieth Century. We cannot trace the period between 1900 and 1915. Suffice it to say that the year 1915 approximates the date of as vigorous an outburst of scholarship in the natural sciences along fresh new lines as the world has ever seen. We can mention only a few of the most typical events

that ushered in the revolution. There were Einstein's theory of generalized relativity, 1915; the Rutherford atom, 1911; the Bohr atom, 1913; the Lewis atom, 1916; transpositional chemistry, 1915 (Franklin's amono-series); Wertheimer, 1912; Lossky's physical organic whole, 1919; Köhler's 'Physische Gestalten,' 1920; Ritter's organismic conception, 1919; Henderson's 'Order of Nature,' 1917; D'Arcy Thompson's 'Growth and Form,' 1917; E. S. Russell's 'Form and Function,' 1916; not to mention the dates of the earlier works of Child, Coghill, J. Huxley, Haldane (the father of the modern organismic movement in Great Britain), Dürken, and a host of others. Here was also the organismic turn in social science, Cooley, Kroeder, Krabbe, A. H. Bentley, and the field theory in cultural anthropology. There were John Dewey, Bradley, Bosanquet and Bergson in philosophy.

By 1930 the term 'Gestalt' was being employed in physics and biology, notably by Schroedinger, Woodger, Bertalanffy, E. S. Russell, Wm. Morton Wheeler and G. E. Coghill. Eddington and Planck were working definitely with physical Gestalten without using the term. Pupin was writing about 'creative coordination' as the message of physical science to humanity. Whitehead had built up a philosophy and logic upon organic wholes. Social science was definitely swinging toward the main current; and public life was turning socialistic again in spite of practical difficulties.

Enough of history. We are, then, in a fourth period, counting the Middle Ages as the first, in which scholarship is concentrating upon the part-whole problem, 1250, 1650, 1820, and 1930. (A study of the cycles indicates that we will have reached the peak about 1940 and another, mechanistic and troublesome 'valley' around 1950–60, to emerge and perhaps permanently to straighten out around 1970 or later, certainly before 2000. A stable world society and a complete resolution of the mechanistic-vitalistic cycles will occur simultaneously because they are aspects of the same cultural pattern.) Three times has scholarship capitulated to the pressure of practical dilemmas, while facing the mass of humanity, and the need for emancipation from some sort of tyranny. Then, as seems perfectly natural, interest, even

in scientific theory, is centered upon the parts. Mechanistic thought, while it has never resulted in a workable, permanent theory of nature, has functioned these three times in support of the needs of the parts in the human whole and has carried scientific theory with it, even to mathematics. It has also added much necessary knowledge upon which to build a better theoretical edifice in the subsequent reaction.

We may now ask the question, Why has the part-whole problem not been solved before? Simply because the human mind has not been relativistic enough. It has been too absolutistic: atomistic, mechanistic and vitalistic. *The solution now in progress is a resolution of vitalism, which had its whole outside the parts, and mechanism, which had no whole, into an organismic position where the parts are actually within a complex, functioning whole. To comprehend such a fact, non-vitalistically, required the concept of the relative, transposable absolute (transposable form) which is a distinct contribution of the twentieth century.* Not that many valuable suggestions were not to be obtained from the past, especially in the conservation principles, like the theories of Le Chatelier and Lenz, and the principle of least action. *Failure to discover that which could change and yet not change kept Wundt, James, Ehrenfels, Stout, Driesch, Ostwald, Whitman, Spencer, indeed all thought from 1890 to 1915 and beyond hopelessly vacillating between mechanism and vitalism.*

There were brilliant anticipations of modern organicism in Ostwald, Mach, Claude Bernard, Paul Janet, Stallo, von Baer, Cuvier, Goethe, Hegel, Kant, even Spinoza, Leibnitz, Th. Aquinas, Lucretius, Aristotle, and Plato. Spinoza almost conceived of a relative-absolute; for Leibnitz the part was as complex as the whole. For Lucretius an end meant a beyond. Aristotle well knew that the part was relative to the whole, and tied up in the destiny of the latter. Wholes were first for Plato. We might trace the beginning back to Pythagoras and his emphasis upon form.

Mathematicians have been studying invariance for centuries, physicists and chemists conservation phenomena for over a hundred years, biologists have always faced the problem, directly, in the phenomenon of growth where the

organism retains its identity and organization in the face of a constant exchange of energy with environment. We have been transposing melodies for centuries, in music, and the flame and the eddy have been repeatedly singled out as hiding one of nature's most important secrets. Here it was, the transposable absolute a fact, old as science itself. It contained the great puzzle of history—how can a thing change and yet not change. It required the same type of mind to solve this problem as to conceive, with no intellectual shock, the fact that a straight line is also a curved one. Thus, *until relativity could be understood, there was no chance of discovering the relative-absolute, the dynamic Gestalt.* This understanding is a universal emergent coming everywhere at about the same time.

Organismic thought is, in reality, *a system of logic*, with definite assumptions upon which an entire, ordered, group of conclusions of necessity follows. These may be called organismic laws, defining laws as universal postulates, to be taken to nature and tested, experimentally. On the basis of these postulates it is possible to predict results in advance. The following postulates of mechanistic versus organismic logic cover the ground about as far as can be gone at present. It can easily be seen that each is an all-or-none system, that there is no compromise and no choice. *The mechanistic at every step turns out to be mystical and self-contradictory, precisely what the mechanist all along has scorned or feared in the organismic position.*

POSTULATES OF LOGIC

Mechanistic-Vitalistic	*Organismic*
1. Parts are logically primary.	1*a*. Complex wholes are logically and dynamically primary.
2. Therefore, they must, in their original state, be unrelated, unbonded, unassociated, for, if they were not, organization and unity would be assumed, *i.e.*, wholes, which is by definition denied. In other words, chaos is primary and order must be derived from chaos.	2*a*. Therefore, by definition, order and interrelatedness are primary. There is no chaos. There never was. There never will be. Structurally any whole that ever existed had parts.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
3. But how? By creative synthesis, bonding, associating, as in chemistry and psychology; or by contract, as in forming a political or economic state. (Herein lies a contradiction and therefore an appeal to mysticism. There are no relations between the parts, by definition, no means of getting them together except by a divine fiat covered up in the word synthesis. Synthesis miraculously derives order from chaos, something from nothing.)	3*a*. All change *from* a given part-whole system, *i.e.*, the coming into existence of new parts, is by differentiation of *form* within the whole. Parts are thus derivative instead of wholes. The process may be called emergent. The new comes from a creative differentiation of the old. There is no mysterious creation of something out of nothing.
4. When parts are primary, unity is derived and secondary (synthesis), or, there is no whole anyway, nothing but the parts (mechanistic view proper), or, the whole is an extra part, called a whole, external to the rest, by its own fiat uniting the parts into an ordered aggregate (vitalism proper). (Alternative one has already been proved to be self-contradictory; alternative two denies order and organization and therefore predictability, which is contrary to fact, and the third makes of the whole a supernatural agent whose existence is not a scientific problem.)	4*a*. Order and system are primary and permanent. Change is from one system as a whole to another, by means of transformation (transposition). The whole retains continuity and identity while the parts change. The parts truly exist within the whole as differentiations from it. 'Whole' *includes* parts. *Parts are identical with a certain portion of the whole.* Therefore *parts plus relations are not additive.*
5. Permanence found in Substance. Parts are indestructible. Wholes are destructible. (Self-contradictory because substance is synonymous with parts and parts are changeable and destructible—parts in a flame, individual in a society.)	5*a*. Permanence found in Form. Wholes are indestructible in the sense that they can be transposed, as in the case of a melody, without loss of identity. Examples: Organism during growth; flame, eddy, memory, recurring perceptions, personality; the state from generation to generation.
6. Absolutistic definitions: Space, time, things. All = ultimate. The whole = sum of parts (contradictory because limits presuppose something beyond).	6*a*. Relativistic definitions of space, time, and things. 'All' is not the end. The whole is more than the sum of its parts.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
7. Part to part causation. Efficient and contingent causes. Explanations often sought in single causes. (Contradictory because parts, to effect parts, must somehow 'divine' what to do. Each part must be omnipotent.)	7*a*. Whole to part causation. Field determination under laws of balance.
8. Historical. Antecedents determine consequences in time. (Self-contradictory because past and present are 'parts' of a time continuum. *Cf.* no. 7.)	8*a*. Ahistorical. Causation is instantaneous. Time relative.
9. Fatalist. Present a passive victim of the past. No emergence. Obedience to the law is absolute determinism. (*Cf.* no. 8.)	9*a*. Present determined by the future teleologically. Emergence. Freedom. Final causation. 'Obedience to the law is Liberty.'
10. Postulates first causes. Attempts to answer the question, 'Why'? (*Cf.* no. 6.)	10*a*. Denies first causes in sense of no. 10, Attempts to answer the question. 'How'?
11. Ultimate explanations metaphysical and supernatural. Explanations *all* vitalistic; or by chance. (Vitalism faces the issue. Chance explains nothing.)	11*a*. Ultimate explanations logical and natural. Describes by means of dynamics.
12. Properties are innate in things. This is sheer vitalism, *e.g.*, weight innate; intelligence innate; acid based on hydrogen ion as a substance (mysticism).	12*a*. *Properties are derived from position of part in the whole.* Weight due to position in gravitational field; intelligence relative to conditions of heredity *and* growth; acid not based on substance but on relation to solvent.
13. Force resides in things (vitalism, mysticism).	13*a*. Force derived from differences in potential.
14. *Direction* innate in force (vitalism, mysticism).	14*a*. Direction is field determined by positions of potentials.
15. The new merely a combination of the old. (Logically denies the new. *Cf.* no. 3.)	15*a*. The new an emergent, not the product of union but of 'pattern completion' or 'closure' under laws of dynamics.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
16. Organization, coordination, integration, explained by entelechy, formative force, creative synthesis or other *deus ex machina*. (*Cf.* no. 3.)	16*a*. Organization not something to be explained but is axiomatic. Always existed and always will.
17. Assumes degrees of organization or unity (contradictory—mistakes degree of predictability for degree of organization).	17*a*. Organization is absolute, and always complete. No such thing as *degree of unity*. This is self-evident.
18. Assumes degrees of functional complexity. Whole more complex than the part.	18*a*. No degrees of functional complexity. Part as complex dynamically as the whole.
19. Denies the existence of an 'ordered' universe, one with a plan logically discoverable.	19*a*. Finds universe 'ordered' and the order logically discoverable.
20. Either denies teleology or accepts a dualistic mysticism.	20*a*. Accepts teleology under laws of balance and equilibrium.
21. By necessity postulates dualisms: mind-body; freedom-determinism; natural-supernatural; organic-inorganic; science-religion; science-art; subjective-objective; order-chaos.	21*a*. Finds dualisms unnecessary, in fact contradictory. Its dialectic harmonizes opposites. Plurality within a unity, universally transposable, eliminates all dualisms.
22. Paradoxical. Unlike phenomena follow unlike laws, hence exist in different universes and must be wholly unrelated. There are no universals. Pluralistic chaos.	22*a*. If there is a unity—a universe—all laws must be universal, and transpose from one set of phenomena to another, no matter how apparently different they are.
23. Structure is primary. Functions are derived. States of being come first.	23*a*. Function or action is primary. Structures derived from function. Becoming is basic; process is fundamental.
24. Elementaristic. The complex is explained by the simple. Postulates indivisibles, or elements.	24*a*. The simple explained by the 'complex.' Form, pattern, system, wholes, are the simplest existing 'things.' Parts, as such, cannot exist outside of wholes. No indivisibles.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
25. Inductive. The general derived and proved by multiplying particulars.	25*a*. Deductive-inductive, or hypothetico-deductive. Perception involves an increment of deduction; the particular possesses an increment of the general and *vice versa*.
26. To investigate one must *isolate* his object.	26*a*. To investigate, one must study *the part in the whole*.
27. Logic and science, fact and theory, observation and interpretation, are distinct and separate. Facts speak for themselves.	27*a*. Not distinct or separate except as parts of a whole. The one relative to the other, and meaningless, alone. Facts do not speak for themselves.
28. Emphasizes structural analysis which is destructive.	28*a*. Emphasizes functional analysis which is not destructive.
29. Objects and events on being subject to law are passive victims of the law. Law is external.	29*a*. Objects and events are *participants*. Law is internal.
30. Parts can act independently of each other in chance fashion. Probability is a characteristic of nature.	30*a*. No independence of parts. Probability not a characteristic of nature, *but merely means unpredictability*, due to uncontrolled but organized flux of causes.
31. The subjective has no counterpart outside of 'consciousness.' The subjective distinguishes the mental from the physical.	31*a*. The subjective is merely the particularity of the part (local, private time; each measuring instrument subjective). Does not distinguish the 'physical' from the 'mental.'
32. Everything that can exist is already formed. Evolution not truly creative.	32*a*. Not all reality already *formed*. Evolution is creative.
33. Measurement leads to laws (contrary to the actual history of scientific laws).	33*a*. Conception of laws necessary for adequate experiment, and necessary for measurement. Statements of the law are then refined and specialized.
34. The infinite is a noun, and is the absolute.	34*a*. The infinite is an adjective, and is the relative.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
35. There exists an *absolute* absolute. The fixed is substance.	35*a*. The basic is the *relative-absolute*. The fixed is form, that which is transposable.
36. The parts are the apparent reals. They are the tangible.	36*a*. The intangible, or whole, is more real than the part because the part is perceived or comprehended with a sense of reality that isolates it erroneously. The greater tangibility of the part is illusory.
37. The indestructible is that which does not change. Permanence depends on absence of change.	37*a*. The indestructible is that which can change and yet not change (*e.g.*, mobile equilibrium; transposable form).
38. Assumes that naïve or ordinary observation and thought result in a correct view of nature. The parts are seen and comprehended first, therefore, they are first in nature.	38*a*. *Naïve thought and observation reverse the actual order of events in nature.* Wholes, the last to be seen and comprehended, are the first in nature (dynamically).
39. Does not distinguish the real from the actual. 'Exist' means 'to be.'	39*a*. Distinguishes two kinds of 'real'—the potential and the actual, the potential or *actually* non-existing, and the *actual* or existing. Exist means *to become*—and is equivalent to *kinetic*.
40. Tolerates inconsistencies and exceptions. One exception does not invalidate a law.	40*a*. Abhors inconsistencies and exceptions. One exception invalidates a law.
41. Permanence contradicts change. Opposites are incompatible.	41*a*. Permanence depends upon change. Opposites mutually dependent and harmonious.
42. Based on additive, linear, and commutative mathematics.	42*a*. Based on non-additive, and non-commutative, non-linear mathematics.
43. Mathematics is the science of measurement and quantity.	43*a*. Pure mathematics is a *qualitative* science of order, series, form, matching, classes, independent of number and measurement. The latter are *applications* of mathematics.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
44. Divide means separate. Number is based on aggregates. $4 = 2 + 2$.	44*a*. Divide means contain. To divide means to individuate. 4 differentiates into $2 + 2$.
45. Based on infinitesimals and discontinuities. *Infinity a noun.*	45*a*. Based on continuities as wholes. No infinitesimals. Infinity a process, *an adjective*.
46. No explanation for evolution, purpose, direction, progress, or vector phenomena.	46*a*. Every process vectorial, a progression, teleological in terms of part-whole fields or systems.
47. Continuity and discontinuity incompatible.	47*a*. Continuity and discontinuity are natural consequences of the energy relationship between *wholes* of different degrees of differentiation.
48. Neglects constant causes as effective in explanations.	48*a*. Includes constant conditions in the explanatory picture.
49. No explanation of error.	49*a*. Error due to premature differentiation, as in atomistic thinking.
50. 'Transmission' of energy explained 'by contact.'	50*a*. 'Transmission' a form of transposition of a *Gestalt*, a case of conservation.
51. Denies analogies. Next object or event may be totally different. Follows from absolutism.	51*a*. Based on analogy. Next object cannot, by definition, differ in the laws of its behavior. Follows from relativity.
52. Fears anthropomorphism.	52*a*. Anthropomorphic error possible only with regard to descriptive, phenomenological, terms.
53. Logically anti-ethical. Pictures blind, purposeless, planless, systemless universe whose laws do not admit of harmony between human strivings and the cosmic system of which human beings are parts. Environment *external to* man. Nature non-ethical. God external and transcendent. Religion a supernaturalism.	53*a*. Logically ethical. Pictures teleological system in terms of dynamics. Environment *includes* man. Natural law is in harmony with human striving. Nature ethical. God immanent and transcendent in sense of 'over-summative' whole. Religion a naturalism that accepts *superhuman realities*.
54. Scientific and moral law are different.	54*a*. Scientific transposable to moral law.

POSTULATES OF LOGIC—*Continued*

Mechanistic-Vitalistic	*Organismic*
55. Agnostic.	55*a*. Religious (not mystical).
56. Science divorces itself from value.	56*a*. Science recognizes value. Depersonalization not required, but logical rigor necessary.
57. Conflict and competition the source of success and evolution. Struggle a cause.	57*a*. Cooperation the source of success and evolution. Struggle an effect.
58. Leads to skepticism.	58*a*. Permits practical idealism.
59. Requires compartmentalization of objectives, scientific and human.	59*a*. Permits complete logical unity of scientific and ethical principles.
60. Leads away from the part-whole problem into over-specialization and mutual misunderstanding.	60*a*. Leads toward a solution of the part-whole problem, toward mutual harmony, and insight into true value of specialization.
61. Leads to disastrous individualism.	61*a*. Leads to collectivism.
62. Leads to nationalism and imperialism.	62*a*. Leads to internationalism.
63. Promotes greed, selfishness, prejudice, lack of sympathy, provincialism.	63*a*. Promotes unselfishness, sympathy, tolerance.
64. Creates ineffective school systems.	64*a*. Creates effective school systems.
65. Different laws in different sciences. Schism between science and philosophy.	65*a*. Same laws in different sciences. Transposes from science to philosophy without change of principles.
66. Laws of science and art different.	66*a*. Laws of science and art the same.
67. Leads to conceit ('chosen' individuals and races, Nordic myths, etc.).	67*a*. Leads to humility and better perspective as regards races, etc.
68. Promotes and justifies war. Men must fight or the race will die out.	68*a*. Repudiates war. The pen is mightier than the sword.
69. Promotes conservatism, 'standpat'-ism. Obsoletism hides behind a show of virtue (except in case of tyranny).	69*a*. Promotes liberalism, improvement, humanitarianism, in times of peace.
70. Handicaps theoretical religion (*i.e.*, concepts of immortality).	70*a*. Assists theology. Immortality logically conceded as a possible case of transposition.

Such is the resolution of the mechanistic-vitalistic antithesis. It preserves the empiricism of past inductive, mechanistic ages, and the deduction of rationalistic ages. It preserves the naturalistic and positivistic advantages of 'mechanism' together with the teleology of vitalism. Contingent are subordinated to final causes. Mysticism is avoided. It saves individualism from chaos and monistic views from absolutism. *It is not an eclecticism.* It preserves *none* of the old definitions, but keeps the problems faced by both systems of the past.

In this resolution, here presented in the right hand column of postulates, there is a shift not only of logic but of feeling. In the past, human attitudes and judgments of value have swung with vitalism and mechanism. Since organismic logic naturally supports the feeling-pattern characteristic of previous vitalistic periods, we have indicated this, as well as the logical shift. After all, feeling and logic are inseparable.

In a series of papers to follow, several of these organismic postulates will be traced historically and discussed at greater length.

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THE JUDGMENTAL THEORY OF PLEASANTNESS AND UNPLEASANTNESS

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Introduction

Every theory of feeling that has gained any prominence or following is either a functional or an analytical one.[1] It has been either an hypothesis concerned with the relations between the feelings and other mental states or it has been a theory of the nature of the affective state itself. The former type has treated feeling as undefinable and unanalyzable, the latter, contrarily, has tried to define and analyze. From Titchener's standpoint and in his terminology, the one may be called 'intellectual,' the other, 'experimental.'

Historically, the functional treatment of affection is older than the analytical. The older theories were inclined to connect feeling on the one hand with thought, on the other, with emotion. Their chief concern was the part played by pleasantness and unpleasantness in the psychic life of the individual. Thus, such conceptions as hedonism and the hormic theory were evolved. The analytical attack on affection began with the advent of a new, introspective, method of scientific observation. This is the method that Titchener referred to as the experimental approach. The psychologist, according to this point of view, must refrain from describing or reporting the purpose or meaning of feeling and limit himself rigidly to observing the mental state. The aim of such observation is determination of the ultimate conscious element or elements of feeling. The outcome of this newer treatment of feeling has been almost complete

[1] The use of terms in the literature on pleasantness and unpleasantness is very often confusing to the reader because of the author's failure to define terms. The words feeling, affection, and their cognates will be used in this paper to mean experiences of pleasantness and unpleasantness.

isolation of pleasantness and unpleasantness from other psychological concepts.

This segregation of the feelings, however, has not been totally a result of methodology. Even before introspection became refined into a method, faculty psychology had carried the schism a long way theoretically. The trichotomy of thinking, feeling, and doing is a tradition in psychology. The outcome of the two influences has been the severance of feeling. The background of both the functional and analytical (introspective) treatment of the problem of feeling has been the bias that the subject matter is unique and irreducible. From both points of view pleasantness and unpleasantness are ultimate.

Perhaps the strongest influence toward impressing the conception of the ultimate nature of feeling on American thought has been the authority of Titchener's opinion. The dichotomy of sensation and feeling is a present-day tradition. This dual-content conception of psychic elements colors, almost without exception, every utterance on the subject of affection. The text-books treat of sensation and feeling in widely separated chapters and as totally different subject matters. Experimentalists carry the dual-content prejudice to the study of feelings as processes. In reading experimental studies of purely functional aspects of pleasantness and unpleasantness (such as, for example, the influence of feeling-tone on memory), one still finds frequent reference in the introduction to the dual elements, sensation and feeling. Thus, a bow is made to the contents which are to be ignored for the remainder of the write-up. Although the content and the functional points of view are logically unrelated, the conceptual dichotomy of contents needlessly causes a dissociation of feelings and other mental processes in many functional experimental works.

Review of the field of affection reveals a chaotic condition. The problems and methods, in particular, are ill-defined and inconsistent. Feeling holds, in this respect, a unique position among the thinly separated domains of research in present-day psychology. There appear to be no universally accepted

guiding principles in this field of study. Agreement is to be found on scarcely a single fact. Different experimenters seem to be describing totally different experiences. Every positive conclusion can be matched with a contradictory one. Such a state of affairs must overtax anyone's idea of a condition of healthy controversy. The source of the disorder is to be found in the prevailing incompatibility of theories of feeling.

In the study of affection, as in other fields, theory leads or misleads experimental research. There consequently follows incongruity of results where totally divergent theories exist. Students of pleasantness and unpleasantness would profit from an attempt to settle the theoretical status of feeling before they proceed with the gathering of more facts about it.

This paper proposes to expound a theory that, in the opinion of the writer, goes far towards attaining such settlement. Not only does this theory give a definite theoretical status to pleasantness and unpleasantness, but it also lends itself easily to the purpose of guiding future research in the field.

The judgmental theory of pleasantness and unpleasantness is not a new one. It was first published in 1925 by Carr, in his text-book of psychology (**3**). Before this time a number of writers had approached very near the judgmental conception, and since 1925 one has outlined an almost identical theory (**16**). The implicit tendency of a major portion of recent thought on affection is in the direction of the judgmental theory. And it can be demonstrated that it is a tacit assumption in many of the experimental studies. Yet in the published reviews of the theories of pleasantness and unpleasantness, the judgmental theory has not been mentioned.

The Theory

Feelings, according to the judgmental theory, are directly dependent upon the activity or movements of the individual. They, pleasantness and unpleasantness, "are attributes we ascribe to any stimulating situation in virtue of our normal

reaction tendency toward it" (3, 290). If the individual normally makes a positive reaction to an object, he labels it pleasant; if he normally makes a negative reaction to it, he calls it unpleasant. The *sine qua non* of affection is the judgment, pleasant or unpleasant, which the individual makes of objects in the light of his knowledge of his own reaction tendency toward them. The conscious content need be in no way different from that involved in any other type of judgment.

Affective judgments may be classed as value judgments, under the caption of which are found many other attributes besides pleasant and unpleasant and which are likewise founded on the reaction tendencies of the individual. Good, bad, attractive, disgusting, admirable, contemptible are a few of these evaluating attributes. Some are broad and others narrow in their implications; and the reactions implied in some overlap those of others. The judgmental theory acknowledges that *pleasant* and *unpleasant* are first of all words and that they, like all words in the language, have meanings gained through experience.

Furthermore, it is profitable to distinguish between the words pleasant (or unpleasant) and pleasantness (or unpleasantness). The former is an attribute that we ascribe to an object in much the same sense that we might ascribe *smoothness* to it. The latter refers to the experience itself which is subjective and exists only as a judgment. When the process by which these terms gain their meanings is analyzed, the general nature of affection will be exhausted.

Pleasantness and unpleasantness are based on the reaction tendencies of the individual. At least a majority of human acts can be classed as either approach or withdrawal movements—either activity which continues the experience or activity which cuts it short. The terms pleasant or unpleasant *mean* that the situation arouses a response belonging to one of these two general classes. Hence, the reactions determine the pleasantness or unpleasantness of the object.

Positive reactions, or movements of approach, and negative reactions, or movements of avoidance—these are the two

opposed groups of reactions that underlie the two contrary qualities of affection. These basic reactions are as manifold as the possibilities of the human repertory of behavior allow, and they may be positive or negative in more than one respect. Approach, or affirmation, and avoidance, or negation, may imply contrary alterations of the spatial relation between object and individual. Reactions may be positive or negative in their influence of the temporal aspect of the experience, either prolonging it or bringing it to an end. Or reactions may accomplish acceptance or rejection of the stimulus by increasing or decreasing the intensity of its effects.

This theory of affection does not state that the individual must necessarily approach every object that he calls pleasant or withdraw from every object he calls unpleasant. *Normal reaction tendency* may be interpreted as the reaction that will occur, other things being equal. The other things that are not always equal are reactions to a present or future object in the total behavior situation, a positive or negative reaction to which requires inhibition of the normal reaction to the object in question. Thus, an individual may judge an object as pleasant (or unpleasant) that he occasionally or even habitually avoids (approaches). It is a fact of everyday observation that the feeling a person has toward an object and his behavior toward the object are two separate things. A man may abhor his profession, yet cling to it tenaciously; another may admit that liquor is certainly an object of pleasure, yet carefully avoid it.

The reactions, whether of approach or of withdrawal, are determined by the purposive tendencies, derived motives, or wishes. If the object is in harmony with the determining tendency of the moment, it is approached; if it is not, it is avoided. Motives and feelings are thus indirectly related. The relation of congruity or incongruity, reinforcing or thwarting, of the object to the motive determines the reaction; and the reaction determines the feeling judgment of the object.

A high correlation between fulfillment of motive and pleasure, thwarting of motive and displeasure, is thus to be

expected. This correlation will not be perfect, however, because the affection is not determined by the individual reactions, which are directly dependent upon the motive, but by the *normal* reaction tendency. Pleasant and unpleasant are terms applied to objects with a high degree of consistency; but the human being does not react consistently in his approach and avoidance movements toward the objects, because he is operating at different times under the influence of different purposes. This imperfect, but high positive, correlation between fulfillment of motive and feeling, which implies an indirect relationship between the two, is borne out by experimental results (1, 294–5).

Pleasantness and unpleasantness are judgments and are forms of cognition. Any treatment of the nature of judgment, theoretical or otherwise, is pertinent to feeling. For the purpose of this paper we may accept the common definition of a judgment as any relationship expressed in a proposition. The proposition expressing an affective judgment may be taken as: 'This is pleasant,' by which the individual means, 'The object pleases me.' The two terms in this proposition are the judger and the object; the relationship, one of pleasing: 'Other things being equal, I react positively to it.'

Precise evidence of the fundamentally judgmental character of feeling is to be found in comparing the results of experiments on hedonic contrast with psychophysical experiments involving judgments of length, intensity, and weight. Beebe-Center makes such a comparison in his book, 'Pleasantness and unpleasantness,' and comes to the conclusion that "absolute judgments of weights and of hedonic-tone are subject to the same general law of contrast" (1, 411–12). It is probable that judgments of pleasantness-unpleasantness and judgments of weight and length are the same in nature.

That theorizers have for so long agreed in overlooking the external similarity of the two types of judgments is remarkable. The experimental procedures used in studies of sensation and of affection are as nearly identical as any two employed in the study of different qualities of sensation. In both the subject is presented with separate stimuli. He is

requested to report judgments; in some cases, absolute, in others, relative judgments. His judgments are recorded. These data are often subjected to identical mathematical treatment in both procedures. Yet in theory this obvious similarity is ignored. The responses of the one type have been viewed as judgmental reactions to some variable of the conscious experience. While in treating those of the other type, the judgmental aspect has been all but left out of account, and attention focused upon ferreting out the unique, conscious element conceived to be somewhere in the experience.

The judgmental theory maintains that there are no conscious contents peculiar to feeling. Experiences of pleasantness and unpleasantness may occur with any possible arrangement of sensory contents. The only necessity is the knowledge of a reaction tendency toward the objective source of the sensation, sensations, or images. And there are no limits to the possible situations that can be judged pleasant.

The prevailing confusion and contradictions in the data of introspections concerning the content of the feeling consciousness is strong evidence for the non-existence of such a content. Theoretically the consensus of opinion can be interpreted to mean that it is sensory in nature. But very little agreement can be found regarding the kinds and limits of the affective sensations. Separate organic sensations, patterns of special bodily sensations, a sensation undeveloped by evolution, are three of the outstanding positions. Beebe-Center, in his review of the entire field of affection, both experimental and theoretical, states the probability that any sensation may be the conscious content of pleasantness and unpleasantness (1, 400).

According to the judgmental theory, emotions may or may not accompany the feeling judgment. The affective consciousness is probably complicated with bodily sensations during the first encounters with the situation. Familiarity with the situation, however, brings a progressive decrease in the emotional element but leaves the affective judgment constant. This conception of pleasantness and unpleasant-

ness as judgments is the only one that gives to feeling and emotion statuses entirely independent of each other. Otherwise the two are hopelessly confused or feeling is made merely a part of, or adjunct to, the emotions.

An adequate definition of *normal reaction tendency* is crucial to a complete understanding of Carr's theory. Thus far, it has been interpreted as 'the reaction that will occur, other things being equal.' Since reactions are actually determined by drives, or motives, the motivation element should receive a place in the definition. Owing to the fact that the motives of a human being are many and often contradictory, the reactions which individual motives require for their satisfaction are often not realized. Thus it is possible that the positive reaction to a particular object may never be made, and the object still be judged as a pleasant one. The individual recognizes the tendency, although he does not make it. The normal reaction tendency is that reaction which would be made if the motive that draws the individual's attention to the object were the only one to be considered. The reaction itself may or it may not have ever occurred. Probably some of the objects which we judge to be intensely pleasant are ones to which we have never reacted. A man may readily admit that opium is pleasant, and yet be one who has never resorted to the solace of it. For the majority of commonplace objects, however, the normal reaction tendency is the reaction that has occurred most frequently.

While the nature of a reaction is determined by the drive, the reaction is elicited by an object. A complete definition of reaction tendency requires a statement of precisely what is meant by an object. The object is not the physical stimulus, but what the stimulus means. By far the great majority of human reactions are to psychological objects (to *universals*, rather than to *particulars*). The circumstances in which an organism reacts to the stimulus as a physical thing are purely adventitious. Affective judgments are reactions to conceptual objects and are based upon normal reaction tendencies to conceptual objects.

Judgments of affective indifference have, so far, been left

out of account. They are seldom encountered in the form of spoken propositions except in laboratory investigations. Indifferent judgments are, however, frequently implied in an individual's behavior. The common layman's attitude toward the non-filterable virus is a surrogate of his affection for it. The academician's behavior toward an adroit hammerlock belongs in the same class. A truly indifferent object is one with respect to which the judger has no reaction tendency. It simply is not a psychological object for him.

The existence of varying degrees of hedonic-tone is also explained by direct reference to the reaction tendency. Degrees of pleasantness and unpleasantness are determined by the energy of the approach and avoidance reactions. The energy of the reaction is, in turn, determined largely by the strength of the motive. Development of all the factors, such as satiety, prohibitions, habit, health, which influence the vigor of the motive would lead us too far afield and require more space than a short paper could envelop.

Carr's theory is unlike any other theory of feeling in that it does not hold pleasantness and unpleasantness to be ultimate experiences. It is primarily a functional conception, because it is an account of the role and purpose of affection in human behavior. At the same time, it analyzes affection instead of accepting it as undefinable.[2] An account of feeling, according to the theory, can be given without calling upon either any new concepts or ones limited to feeling alone. The theory thus brings affection into intimate kinship with other psychological experiences.

Perhaps the main flaw in the force of this theory of feeling is that it can be so clearly and briefly stated. Pleasantness and unpleasantness are terms applied to objects with reference to the normal reaction tendency toward them; and the terms actually mean the two opposed reactions. With the pre-conception that pleasantness and unpleasantness are highly complex (*i.e.*, poorly understood) and ultimate phenomena, many will be inclined to turn away on this ground.

[2] The type of analysis referred to here is not that of trained introspection, but a combination of logical analysis and common sense introspection.

However, the true value and illuminating effect of the judgmental conception becomes apparent when its implications for fact and theory are examined in some detail.

Introspective Facts

The group of facts to be considered first are those that grew out of the study of feeling as an element of consciousness.[3] The following are the chief questions that these studies have attempted to answer: (*A*) Are feelings localizable? (*B*) Can pleasantness and unpleasantness coexist in the same state of consciousness? (*C*) Can a feeling occupy the focus of attention? (*D*) Do the affections show qualitative opposition? (*E*) Can a feeling occur in isolation from other mental contents? (*F*) Are they subject to adaptation? (*G*) Are they more subjective than the usual mental state?

Introspective experiments have furnished us with both positive and negative answers to all seven of these questions. Where then are the facts? Strictly speaking, it looks as if there were none here that a theory must necessarily meet. The thing that calls for explanation in connection with the answers to these questions is the fact of the contradictory results of different experimenters. There have been many explanations offered to this problem. Somewhere in the presentation of every recent theory of feeling, its author attempts an answer, usually in terms of criticisms of introspection as a method, or of the vicious influence of systematic bias on introspection. None of these has been entirely satisfying to the present writer. If the problem be examined in light of the judgmental theory, however, a more adequate explanation is revealed.

Pleasantness and unpleasantness are judgments, and hence come under the broad caption of meanings. They are for this reason excluded from among the objects of introspection because, by definition, introspection is the observation of the

[3] The experimental source of all the facts referred to will not be given in this paper. For references, the reader is referred to the many reviews. The most inclusive of the reviews of the literature on feeling is to be found in Beebe-Center's 'Pleasantness and unpleasantness' (1).

contents of consciousness shorn of all meanings. Meanings belong in the class of relationships; and the premises of the introspective method excluded relations from among the contents, or givens, of consciousness. According to the judgmental viewpoint then, the essential reason why experimentalists have differed on the nature and characteristics of the feeling content is that they have failed to observe the feeling judgment, which is, by definition, not a content at all.

There remains to be answered the question of just what the experimentalists on affection or their trained subjects did observe. They observed different sensations. Some, who were not well trained, made the affective judgment and observed the objective situation; others observed the intra-organic (emotional) and kinesthetic (incipient movements of approach and withdrawal) that may, and frequently do, accompany the judgments of an object as pleasant or unpleasant. The former were accused of making the stimulus error; the latter accused each other of observing different sensations instead of the affective content, a criticism partially true, because they were variously identifying the affective element with the sensations from different proprioceptors. This explanation gains support when we turn to the detailed account of the facts of affection and find that there is a striking similarity between the qualities ascribed to the organic sensations and to the affective element.

The following reckoning of the introspective problems of feeling will give the answers of the judgmental theory and also will account, where possible, for the common positions (held by many in spite of the experimental contradictions) on the assumption that they are the result of what has been most commonly observed, *i.e.*, proprioceptive sensations, as pleasantness and unpleasantness. The judgment and the somatic disturbances, however, are two separate things. Affective judgments are often accompanied by proprioceptive sensations. These are the sensations most characteristic of the emotional consciousness; and, although feelings are distinctly not emotions, they are frequently joined with them. Exteroceptive sensations also accompany affective judgments, and

perhaps more frequently than the proprioceptive. Furthermore, proprioceptive sensations are correlated with other types of judgments, such as the moral and aesthetic. Yet this sensory content is not held to be the necessary factor in these judgments. While the correlation between organic or kinesthetic sensations and the affective judgment is granted, the judgmental factor is distinct from the sensory and is maintained to be the only *sine qua non* of affection.

(*A*) Are feelings localizable? A judgment of pleasantness or unpleasantness cannot be localized any more than can any other relationship. In the light of Carr's theory, this question is as irrelevant as that of the localizability of goodness or badness. In the everyday manner of speaking we localize both pairs of qualities in the object, and only on reflection recognize that they are subjective and in this sense in ourselves. But to say where in ourself they are located is out of the question. The sensations that accompany the affective judgment, however, can be localized by referring them to sense organs with various degrees of certainty. Those of the viscera and the muscles, which we have concluded were most frequently observed, are proverbially difficult of localization.

(*B*) Can pleasantness and unpleasantness coexist in the same state of consciousness? This question is more difficult to answer than the preceding. If we knew precisely that any two judgments, one of which did not imply the other, could be present in consciousness during the same fleeting moment, the affirmative answer could be given without hesitation. By whatever means one may expect to arrive at an answer to this question, one may be certain that it will not be by the route of introspection, for how can one possibly be sure that the two judgments have not alternated at such a rapid rate that simultaneity has not been just approximated? Ask yourself this question: Can the judgments of remoteness and nearness be present simultaneously? The answers to the two questions are the same.

The nature and origin of the proprioceptive sensations, which frequently accompany affection, account for the common opinion concerning the coexistence of pleasantness and

unpleasantness. The visceral organs have been found to respond in a diffuse fashion and in such a way that the same organs are operative in emotions which are described differently with respect to feeling. It is conceivable that the correlate of the conscious feelings of pleasantness and unpleasantness are different patterns, temporal or spatial, of visceral innervation. The two patterns probably could not occur simultaneously, in this case, since it is likely that they would involve the same organs. In as much as these sensory contents depend upon the implicit muscle movements, and in as much as feeling is identified with sensory content (a position denied by judgmental theory, however), the question of simultaneity could be answered in the negative.

(*C*) Can a feeling occupy the focus of attention? When one is judging an object as pleasant he is reacting to the object. This judgmental reaction to the object is the pleasantness and, in order to maintain it, the person must attend to the object or to the sensations from the object. If the attention be taken from the sensations and given to the reaction, the judgmental reaction as such ceases. Hence, according to the judgmental theory, a feeling cannot be the subject of attention.

When the feeling is identified with the organic reverberation, two explanations can be offered for the negative answer to the question of whether or not feelings can be attended to. In the first place, visceral and kinesthetic sensations are usually too vague and weak to yield to the analysis of attention. In the second place, organic reactions, like judgmental ones, are reactions to the stimulus object. The reactions cease when the object is no longer attended to.

The remaining (the fourth through the seventh) of the questions listed above are concerned more with the relationship of feeling to other elements and mental states, and are more valid problems for a theory of feeling (especially for one that denies an independent content for feeling). Psychologists are in more agreement in answering these questions than they are on the first three listed.

(*D*) Pleasantness and unpleasantness are qualities or attributes that we ascribe to psychological objects, and these qualities are opposite ones because they are based on opposite reaction tendencies.

(*E*) In answer to the fifth question, feelings never appear without the accompaniment of sensations, because consciousness is never free of sensations and because feelings exist only as reactions to situations which are either sensorially or ideationally present.

(*F*) Affections of both qualities wane with repetition of stimulation or with continued stimulation because in the feeling reactions, as in any other type of reactions, the individual becomes adapted to the object. Adaptation means that continued stimulation is followed by decrease in response. Accordingly, since they are judgmental reactions, pleasantness and unpleasantness are to be expected to decrease with continued presentation of the object. It has long been recognized that the richness of meaning attenuates with frequent or continued appearance of the object.

Sheer continuation of a stimulus constitutes in itself a psychological object, *i.e.*, one of monotony, to which an individual may react independently of the persistent object. Continued or intermittent repetition of a condition may also give rise to satiety, an independent psychological object. Human beings usually react negatively to both monotony and satiety. Thus, we find pleasure not only diminishing but also changing to its opposite, displeasure.

(*G*) Pleasantness and unpleasantness are undoubtedly subjective in the sense to which all other meanings of subjectivity-objectivity are reducible. According to this sense of the terms, the objective is any event or relationship upon which the reports of a great many people agree; the subjective is a relation upon which there is very little agreement, or one upon which only one person can report. Subjectivity and objectivity represent the two extremes of a continuum. Organic sensations as well as judgments, one term in the relation of which is the ego, belong in the class of subjective relationships.

Functional Facts

From the study of affection as a process in functional relation with other processes, a new set of problems and experimental results has been reaped. These problems are receiving the active attention of present-day experimentalists with the tacit recognition of the inadequacy of the introspective method of the esoteric variety and the futility of the content-attitude. The results of these studies is in perfect agreement with the view of feelings as the recognition of a reaction tendency, although the findings on any one problem are too sparse for any very final conclusions.

(*A*) The reaction-time for feeling-tone has generally been found to be longer than the sensory reaction-time. In the case of the sensory reaction, the subject perceives the stimulus and reacts; in the feeling reaction procedure, the subject perceives the stimulus, discriminates on the basis of his knowledge, and reacts. Reactions of discrimination, choice, and judgment have longer latent times than simple sensory reactions.

(*B*) The relations between feeling-tone and bodily response are among the most interesting and pertinent for theory. The experimental results here are not in entire agreement. There is in general a tendency for pleasantness and unpleasantness to correlate with approach (flexion) and withdrawal (contraction) movements, on the one hand; and on the other, with relaxation and tension. These two tendencies appear to supplement each other when one recognizes that there are actually two attitudes toward pleasant-unpleasant objects: the active and the passive. These are the ascendant and submissive roles in behavior. These attitudes, or roles, in turn depend upon the nature of the object, whether it is stationary or moving and in what direction it is moving. If the object is moving toward the individual, relaxation favors approach, and conversely for tension. Approach and relaxation, in either case, foster continuation of the experience; withdrawal and tension, cessation of the experience.

There apparently does not exist a perfect correlation between pleasantness-unpleasantness and the two types of behavior. Nearly a perfect correlation could be expected if the motivation factors in human beings were as simple as those in the amoeba; in the human being, the determinants of behavior are more complex. Whereas the individual approaches an object when under the influence of one drive, he may very well avoid the same object when an opposing drive is operative. For an object judged pleasant, positive reactions are expected to occur more frequently than negative; and conversely for an object judged unpleasant. In any one experiment, involving (as is usually the case) a large number of stimuli of relatively indifferent feeling tone, a positive correlation between pleasantness and approach is to be expected if the judgmental theory is true. As far as the experimental results go, this is what has been found.

The judgmental theory does not demand a perfect correlation between these two variables in another respect. The reaction upon the knowledge of which the judgment is based need not occur every time the affective judgment is made. Especially with reference to familiar objects, the judgment may suffice and the reaction be inhibited.

(*C*) A problem that most theories of feeling have ignored is that of the existence for human beings of two kinds of pleasures, the so-called higher and lower pleasures, or the intellectual and the sensuous. There is a difference of some kind between the pleasures we ascribe to a Beethoven symphony and to an early morning plunge; the pleasures of a Rembrandt portrait and of a sip of Benedictine. Probably no one would deny this difference, but some would consider it one of degree, others, one of kind. It is possible to assume either view of this difference if the concept of feelings expounded in this paper be taken. One could maintain that the two types of pleasurable experiences differ only with respect to the degree that they involve organic sensations accompanying emotions. One could also view the two types of experiences as differing in kind, at the same time admitting that the essential natures of both are judgmental. They

differ, on the one hand, with respect to the kind of sensations that accompany the feeling consciousness of everyday life. The higher pleasures involve sensations conveyed by the distance receptors and bear no necessary dependence upon organic or somatic sensations; the lower pleasures involve primarily organic sensations and are only indirectly aroused by the distance receptors. On the other hand, they may be said to differ with respect to the kind of motive with which the object is congruous or incongruous. Some human motives are inborn or directly dependent on inborn factors; others are purely a product of training. The former are the kind underlying the lower pleasures; the latter underlie the higher pleasures. However, regardless of which of these two views of the difference is taken, the vague borderline between the two types of pleasures—a gap that appears in all other theories—does not exist for the judgmental theory.

(*D*) The influence of training on pleasantness and unpleasantness is another fact of common everyday observation that other theories do not easily account for. Different civilizations, different social groups, and the people within narrow communities vary considerably in the objects they consider pleasant and unpleasant. The Chinese music is unpleasant to the European ear; the European music is unpleasant to the Chinese ear. Beer is pleasant for some Americans, unpleasant for others. No object or situation is innately pleasant or unpleasant, any more than any other judgment or knowledge is innate. Pleasantness and unpleasantness are the outcome of training. Even the sweet taste of sugar is pleasant only after we find that we seek it. The individual must learn that he approaches or avoids objects—because they are congruous or incongruous with his motives. This does not imply that the individual is necessarily aware of his motives. He is aware primarily of his reactions.

(*E*) One reads repeatedly and from widely different sources that pleasantness and unpleasantness are primitive in nature, that in terms of the phylogenetic scale feelings are very old. This opinion is well founded in the sense that the

reactions of approach and withdrawal upon which feelings are based find their prototype in the trophic and atrophic responses of unicellular animals. It should be remembered, however, that the affection itself is a conscious phenomenon and limited to those organisms which can give a verbal or other form of symbolic report of their possession of the reaction tendency.[4] The affection is not the reaction but the judgment.

The pristine quality of feelings has also been asserted in quite another sense. Titchener concludes his description of the feeling element by likening it to a sensation undeveloped by evolution (**21**, 291–2). In so far as the feeling consciousness commonly involves sensations from the autonomic nervous system, which is the remains of a phylogenetically ancient nervous system in the body of the human being, pleasantness and unpleasantness are primitive.

(*F*) At the present time very active experimental interest is being displayed in attempting to determine the relation between feeling-tone and memory. A great deal of data has been collected on the problem, but no adequate statement of the relation between affection and memory has yet been reached. To clarify the nature of this relationship is, in the mind of the writer, one of the important roles of the judgmental theory.

Two types of reactions fall under the caption of memory. One of these is a negative reaction of elimination, called forgetting; the other is a positive reaction of fixation, called remembering. These two types are respectively coordinate with avoidance and approach as tendencies of reaction. Thus when I recall an idea, I am reacting positively to the object of that idea; when I recall certain words from a list once learned, I react positively to those particular words.

[4] It is very doubtful, according to the judgmental theory, that animals experience pleasantness and unpleasantness. In order to determine whether or not they do, one would have to demonstrate that some movement of theirs that is not involved in overt approach or avoidance could act as surrogate, or symbol, of possession of the tendency. It is certainly highly improbable that all species are capable of such a symbolic report. In studying the feelings of an animal possessed of such ability, one would deal with the symbolic movement and not with the overt movement.

Conversely, to forget an idea or certain words in a list is to react negatively to them.

The judgmental theory of feeling indicates a dependent relationship between memory and affection which is the opposite of the generally accepted opinion. Memorial reactions, like all reactions of the antipodal types, share in the determination of pleasantness and unpleasantness. Paradoxically, we may thus say that a thing is pleasant because we remember it and unpleasant because we forgot it.[5]

This relationship, however, is an indirect one. As has been previously stated, affections do not depend upon the individual reactions, but upon the average or normal reaction. Although a person's most frequent reaction toward an object may be one of negation, he will occasionally make a positive reaction to it. Meanwhile his judgment of the object as unpleasant remains constant.

Memory is directly related to the consequence of behavior, or what has come to be known as 'effect.' By effect is meant the congruity or incongruity of a reaction (as aroused by the object) with the motive or determining tendency of the moment. When the reaction is congruous, the object is approached (or remembered); when the reaction is incongruous, the object is avoided (or forgotten). The congruous or incongruous effect varies with the motive. The human being has a variety of motives, one or more of which dominate his behavior at any one time. The effect with reference to an object is determined by the motive dominant at the moment of reaction. The feeling values of objects, however, as labels that we apply to them, do not so change with the changing motive. The pleasantness or unpleasantness is determined by the most frequent type of reaction toward the object.

This conception of the relation between feeling and memory requires a sharp differentiation between feeling and effect. It is apparent that the two are different concepts in several

[5] This correlation between feeling-tone and memory is not a perfect one, any more than is the correlation between feeling and any other type of reaction. When I recognize that I do quite frequently forget an idea or that I have a strong tendency so to forget it, I judge the idea to be unpleasant. And the relationship means nothing more.

respects. In the first place, the sensory consequences, or effects, of activity are not always conscious. This has been experimentally demonstrated. Pleasantness and unpleasantness are affairs of which the subject is conscious. The fact that feelings as a separate experimental problem are a conceptual legacy of introspective psychology is enough to insure them as phenomena of which the observer is aware. An unconscious affection is as inconceivable as an unconscious sensation. In the second place, they differ in their causal relations to behavior. Effect exerts a direct causal influence on behavior; feeling has only an indirect causal influence in the matter of planning future lines of activity in the light of past reactions. The latter of these two, which is the function of pleasantness and unpleasantness in behavior, is also the function common to all forms of knowledge. And lastly, the two differ with respect to their dependencies on motives. Effect depends directly on the motive. With changing motive the effect of an object changes. The feeling tone ascribed to an object is only indirectly dependent on the motive, in that over a period of time the average of the organism's totality of determining tendencies brings about a common type of reaction. With shifting motive, feeling judgments do not alter. A change of motive with resultant change of behavior, does not alter the fact of the normal behavior tendency on which the feeling tone is dependent.

The mist that has shrouded an understanding of this relationship between affection and memory is the result of failure to analyze it in the light of the judgmental conception. The chief implications of this conception are, in summary: (1) that memory and feeling are indirectly related; (2) that feeling is dependent upon memory, rather than memory upon feeling; (3) that feeling and effect are totally exclusive of each other.

In experimental attacks on this problem feeling-tone has been treated as if it were independent of behavior and somehow belonged to the object judged in somewhat the same sense that its color or shape belongs to it. The cause of this misconception can be traced to the influence of the dual-

content attitude of consciousness that ruled the introspective studies of affection. As a consequence the methods used in these experiments have not been adequate to furnish the complete data desired. Yet the general results of these experiments are not incompatible with the judgmental theory. Let us examine the two methods used most frequently.

One method used in the study of feeling and memory is that of free-recall. The subjects are asked to recall events and then to label these pleasant or unpleasant. The general result has been that more pleasant than unpleasant have been recalled, but that the difference is not great enough to conclude that unpleasant feeling-tone causes forgetting or that remembering is dependent upon pleasant feeling-tone. How is this finding to be interpreted? According to the judgmental conception, the events recalled were those compatible with the motives dominant in the subjects at the time of recall. The judgments of pleasantness and unpleasantness by the same subjects are based on the normal reaction tendencies, which are dependent, not on the dominant motives of the moment of recall, but on the motives most frequently dominant in everyday life. Accordingly in a large number of events recalled on any one occasion, a predominance of pleasant ones will prevail, but in so far as the motives of the recall period differ from those usually in operation, a few unpleasant ones will appear.

This finding has been misinterpreted as proving the falsity of 'Freud's theory of forgetting,' that we forget the unpleasant and remember the pleasant. The pleasant and unpleasant in Freud are not the same feelings to which we refer the terms in academic psychology. The factor that operates in many forgettings, according to Freud, is not necessarily a conscious one. The experiences of pleasantness and unpleasantness referred to in this paper are exclusively conscious events. Freud's theory is actually another statement, with a new setting, of the law of effect: we forget what is not compatible with the motives or drives operative at the moment. In his examples of everyday forgetting, he does not

imply that the forgotten word will never be recalled. He merely describes the common occurrence of inability to recall a word at one moment with recall of the word on a subsequent occasion. The motive with reference to which the word was incompatible was dominant at one moment, not at the other. Freud's theory (as well as the ones in terms of the law of effect) would be better stated as follows: we cannot recall a word that is incompatible with the determining tendency of the moment.

Another method employed in studies of feeling has been to have the subjects judge words as pleasant or unpleasant, arrange lists of different feeling-tone, and have the subjects learn the lists. The usual finding here is that the two are learned equally well. This method and result can be interpreted as follows. The subjects judge the words according to their normal reactions of everyday life which are determined by the prevailing motives. In the subsequent learning situation the subjects are dominated by a determining tendency to remember, which is compatible with retaining equally well the pleasant and unpleasant words.

Present-day Tendencies

The judgmental theory of pleasantness and unpleasantness is in harmony with present-day trends in experimental and theoretical studies of feeling. It is in agreement, for one thing, with the present-day tendency to avoid the content-attitude of affection. Recent experimental work and theories have assumed the functional attitude toward the problem and implicitly ignored the content altogether. The only notable exception to this tendency has been the work on bright and dull pressures by Nafe and others. Through analysis of observers' introspective reports of their conscious contents during feeling experiences, Nafe arrived at internal pressure sensations as the content typical of affection (17). The pressure is dull and located in the abdomen for unpleasant experiences; it is bright and located in the chest for experiences of pleasantness. The terms, 'dull' and 'bright,' are merely ones that best approximate the qualities of the pressures for which there actually exist no appropriate epithets.

According to Nafe, these patterns of sensations *are* pleasantness and unpleasantness. Hunt (**6, 7, 8, 10**) and Wells (**23**) have verified his results to the extent of finding a high correlation between the experiences of bright and dull pressure and pleasantness and unpleasantness when the subjects assume the proper attitude toward the experiences. 'Bright pressure' and 'dull pressure' are admittedly only names for syntheses of bodily sensations, the specific individual sensations being unknown. And the pressures do not invariably accompany the affective judgments. Hunt's interpretation of these sensations and their correlation with affective judgments is a more likely one than Nafe's (in view of the arguments included in this paper) and one that makes them compatible with the judgmental theory.

Hunt interprets "pleasantness and unpleasantness as conditioned verbal responses, back of which may lie the experience of bright or dull pressures" (**9**). The two types of pressures are sensory reverberations from bodily adjustments of positive or negative reactions to stimuli and pleasantness and unpleasantness are names for the two pressures. In the course of frequent repetition of any affective experience, the pressure experience may be omitted by the shunting process that occurs in all behavior, and the name, pleasant or unpleasant, be given directly to the stimulus. Thus the words pleasant and unpleasant mean the bright or dull pressures which are organic sensations resulting from bodily adjustments of approach and withdrawal. This theory differs from the judgmental only in the matter of the specific meaning it ascribes to the terms pleasant and unpleasant. This difference is a significant one, however. According to the judgmental conception, the words pleasant and unpleasant mean the most prevalent or the normal bodily adjustments made, rather than their individual sensory reverberations. It is still not inconsistent with the theory to hold that these sensory patterns frequently accompany the feeling.

Students of affections have in recent years come to fairly close agreement on the intimate connection between meaning and affection. Yokoyama, in an introspective study of the

nature of the affective judgment, came to the conclusion, "that P and U are most universally and definitely statable as meanings," and that in content they are sensory (**24**). In an article on 'Feeling and knowing,' 1929, W. D. Tait points out the identity of the two, maintaining that feeling is a primitive sort of knowing (**19**). The trend of this conception is in close harmony with the theory expounded in the present paper. And more recently still, J. H. MacDonald published a series of reflections on the problem of feeling in which his major conclusions are that "'affect' and 'idea' are not only concomitant but also specific and inseparable one from another" (**11**). These are but three examples from many that appear among the studies of feeling. There is clearly a modern tendency to classify affection as a type of meaning.

This tendency has elicited the following two criticisms from Young (**27**, 28): (1) that meaning is an ambiguous term; and (2) that in his studies the difference between cognition and feeling has been repeatedly pointed out (**26**). In defense of the second of these criticisms, Young admits that in many feeling judgments, if an intellectual attitude be taken, the meanings of pleasantness and unpleasantness are attached to the objects; but that there is no guarantee that the feeling experience is really *felt* (**25**). In other words, every affective experience involves the judgment, pleasant or unpleasant, and some of them also involve the *felt* experience. The latter is the true affection. A detailed answer to this criticism would entail repetition of a great part of what has preceded in this paper. The criticism loses its force if a special, necessary content of any kind is denied feeling. The 'felt' experience referred to by Young is the synthesis of organic sensations, bodily reverberation, that may or may not accompany the judgment.

To the first of Young's criticisms, that meaning is ambiguous and that therefore feeling should not be identified with it, there is a very obvious reply. If we temporarily grant that meaning is ambiguous, for the very reason of its ambiguity we would be inclined to identify feeling with it. For surely if there has been an ambiguous concept in psychology, it

has been that of feeling. It is the tenet of the judgmental theory, however, that the equivocal nature of the feeling concept has resulted from failure to identify it completely with meaning.

Meaning is an ambiguous concept only from the narrow, exclusively qualitative viewpoint. In search for conscious 'substances' the content-psychologist ignored the reality of conscious relations. Exclusive of psychological writing pervaded by this viewpoint, meaning has had more or less definite shape since man first became interested in the problem of knowledge. Although there exist several apparently distinct theories of meaning, all agree in identifying it with one or more aspects of the redintegrative, symbolic feature of mental events (5). An event is meaningful in so far as it is symbolic. As a process meaning is the long recognized functioning of one event in place of (as substitute for) another (usually more inclusive) event. And in the hands of experimental psychologists the concept has crystallized into learning. Its forms have been found to be as manifold as the forms of behavior, from the most simple to the most complex, from the conditioned response to ideation and concept formation. The concept of meaning is ubiquitous, but not ambiguous.

It is, moreover, becoming more widely recognized every day that meaning is the central concept of psychology; that actually it defines the subject matter of the science.

The present-day view of meaning does not limit it to conscious events alone. Meaning may be unconscious as well as conscious. All the term consciousness necessarily implies here is awareness with ability to report; and the conscious form of meaning is the judgment, whether it be stated as a proposition or not. Pleasantness and unpleasantness are such conscious meanings, symbolizing the organism's normal reaction tendency toward the situation.

Parallel with the tendency to class feelings as a kind of meaning has gone the trend to base them on the reactions of the organism. Recognition of the dependence of pleasantness and unpleasantness on reaction tendencies is relatively old in affective speculation. In an article published in 1906,

Washburn expresses the relationship most clearly. "Finally, pleasantness and unpleasantness occupy a unique position among the unanalyzable and unlocalizable processes, as representing the most fundamental of all primitive motor attitudes, the positive and negative reactions" (**22**). Binet, in a theory of feeling that closely approaches the judgmental, bases pleasantness and unpleasantness on the two opposed reaction tendencies (**2**). Paulhan (**18**) and Claparède (**4**), to mention only two more, utilize this dependence in their theories of feeling. However, all of these theories differ from the judgmental theory on the other features of the affections and particularly in that they assume the feeling itself to be unanalyzable. Of the theories that rest heavily on the dependence of feelings on reactions McDougall's is the only one that needs careful distinguishing from the judgmental theory, because of its high degree of completeness and its close resemblance to the judgmental theory.

"The hormic theory . . . asserts that conation (action, attention, striving, desire, volition, activity of every kind) is immediately determined by cognition, and that pleasure and pain result from the conation, are determined by the striving; pleasure, when the striving attains its natural goal or progresses toward it; pain, when striving is thwarted or obstructed and fails to achieve, or progress toward, its goal" (**12**, 269). This statement of his hormic theory is taken from the 'Outline of psychology,' 1923, a formulation of the theory that he continues to hold without essential alteration (**12**, **13**, **14**, **15**). Pleasantness and pain (unpleasantness) are, according to this theory, the immediate results of activity and subsequently determine the continuation of or the cessation of the activity. Pleasure and pain are the effects of reactions.

Substitute the terms congruous and incongruous consequences for 'pleasure' and 'pain' (unpleasantness) in the above expression of this theory and add that the normal reactions determined by these cause the pleasantness and unpleasantness and you have approximately the judgmental conception. When these two, superficially minor, changes are made, a fundamentally different conception of affection results.

The pleasure and pain that McDougall refers to (and that we identify with the 'effects' of conative impulses) determine the desirability or undesirability of objects. But it is a distinguishing feature of the judgmental theory that it denies the identification of desirable with pleasant and undesirable with unpleasant. Desire and pleasure are not the same thing. If we cease to desire sugar with satiety of the sweet taste, we do not then cease to label the sugar as pleasant!

Desirable and undesirable objects mean objects to be sought and objects to be avoided. Yet everything sought is not judged pleasant; and every object avoided is not labeled unpleasant. The pleasant object is one that we normally seek; the unpleasant, one that we normally avoid. On the basis of the knowledge of these normal tendencies we label objects pleasant or unpleasant.

The point the writer is trying to make here is practically the same one made above in defining the relation of pleasantness and unpleasantness to the law of effect. As the writer sees it, McDougall's hormic theory is a very adequate picture of a truth that other academic psychologists (not all so early as he, however) have recognized under the caption of the law of effect.

Thus the judgmental theory differs from the hormic theory by being a more inclusive one. McDougall's failure to analyze pleasantness and unpleasantness leads to the ascription of functions to them that are not implied in the judgmental theory. According to McDougall's formulation of the hormic theory, pleasantness and unpleasantness exert a direct causal influence on behavior, in that they stamp in or eliminate, foster or cut short, reaction tendencies. The influence of pleasantness and unpleasantness on behavior, according to the judgmental theory, is the same as that of any other body of knowledge: that of being utilized in the service of conative impulses for the planning of future lines of activity.

The hormic theory and the judgmental theory also differ in the roles they ascribe to pleasantness and unpleasantness in evolution. The problem here is that of accounting for the

consonance of welfare and pleasure. Why is pleasantness correlated with the beneficial and unpleasantness with the detrimental? Of course the correlation is not perfect but it is high enough to maintain the existence of some species and races. Those races of human beings for which the correlation is not very high are at present dying out. If we are not to admit that this correlation was determined by a beneficient Providence at some point in the course of evolution, McDougall asserts, we must grant that pleasantness and unpleasantness exert a direct causal influence on behavior. "If pleasure really sustains action and tends to bring about repetition of similar action under similar circumstances, as it seems to do, then we can understand that those creatures which found pleasure in actions that are beneficial to themselves will have had in the struggle for existence great advantage over those to which such actions were not pleasurable; for they will have tended to repeat such beneficial actions. Still more will they have had advantage over those of their species to whom such beneficial actions brought pain; for those would have avoided all repetition of such actions" (14, 77). Thus McDougall's solution of the problem of consonance of welfare and pleasure is that those species only have survived that found pleasure in the beneficial and, consequently, sought it. Those species that experienced unpleasantness with the beneficial accordingly avoided it and did not survive.

What solution does the judgmental conception of pleasantness and unpleasantness have to offer for this problem? The problem really does not exist for the theory. If the pleasant means just what we seek, and the unpleasant, what we avoid, of course there is going to be coincidence between the two opposed qualities and the two opposed reaction tendencies. 'Pleasant' and 'unpleasant' are merely attributes that we ascribe to objects that we seek and to objects that we avoid. The fact of our survival is evidence enough that in general what we seek is beneficial and what we avoid is detrimental. We have survived because of this close coincidence. Thus it happens that by evolutionary elimination the objects we seek

and the objects good for us correlate to some extent. Pleasant objects *are* objects that we seek. Therefore pleasantness and welfare are correlated to the same extent.

Again the writer feels that the issue will be clarified by pointing out that what McDougall refers to as pleasantness and unpleasantness are the thwarting and reinforcing consequences of activities which, according to the judgmental conception, are only indirectly related to pleasantness and unpleasantness.[6]

Experimental Prognosis

It has probably occurred to the reader at some time in the course of this exposition of the judgmental theory that the theory sounds very well, but that, after all, it is very general in its scope and not one to lend itself to experiment. Granted, the theory is a broad one, but so also are affective phenomena broad ones. Explicitly or implicitly, feeling judgments accompany, at least potentially, every conscious reaction a human being makes. They are varied in kind as well as frequent in occurrence. For such an ubiquitous fact there must, necessarily, be a theory of wide scope. But the reader is wrong if he assumes that the theory is foreign to experimentation. The judgmental theory is experimentally verifiable; and it points students of affection toward a new and promising experimental method.

A number of the implications of the judgmental conception have already been verified in previous experimentation. To indicate each of these would be to reiterate a great deal of what has preceded in this paper. Two of the more pertinent are (first) the indication of a high degree of correlation between approach movements and pleasantness and between avoidance movements and unpleasantness, and (second) demonstration that feeling judgments follow laws identical with

[6] This fallacy underlying McDougall's explanation of the consonance of welfare and pleasantness has already been observed by D. S. Miller in an article, published in 1929, entitled 'The pleasure-quality and the pain-quality analysable, not ultimate' (16). In this article the author outlines a conception of feeling that is the nearest thing in the literature to the judgmental theory. Miller was unaware of Carr's previous publication of the same theory and how it accounts for the consonance of welfare and pleasure (3, 302), or at least he makes no reference to Carr's exposition.

those that prevail for other types of judgments. Further such verification is, of course, desirable. Especially desirable is further demonstration of the similarity of affection to other types of judgments.

It is possible to attack verification of the crucial phase of the judgmental theory by means of an experiment designed solely for that purpose. Such an experiment has never been performed, but it is easily possible to outline one. For example, the following procedure could be used, in general. Let a number of subjects be required to judge as pleasant, unpleasant, or indifferent, a long series of definite and relatively indifferent stimuli objects. Let the subjects then be put through some procedure in which they are required to make one of three reactions, acceptance, rejection, or ignoring, to every stimulus object in the prejudged series. The procedure would be some sort of learning set-up in which each subject would have to make the necessary reaction a great many times. Instructions would be necessary to superimpose a set determining the reactions to be given the individual stimuli. A second affective judgment of the series of stimuli objects would be taken after completion of the learning. Verification of the judgmental theory would lie in demonstrating a high degree of correlation between the types of reactions and the subsequent feeling-tone. In doing this, it would be necessary to take into account any changes, and the direction of change, from the first judgment to the second judgment of the hedonic-tone of the stimuli objects.

The judgmental theory clearly points the way for other research in the affective processes. This is in the direction of the measurement of attitudes opened to experimentation by Thurstone. From the traditional methods of psychophysics developed for measurement of judgments of stimuli intensities, Thurstone has derived procedures for measuring judgments, or social attitudes, of any psychological object. Detailed derivation of formulæ and laws of this methodology are to be found in his numerous publications. His presidential address to the Midwestern Psychological Association, entitled 'The measurement of social attitudes,' presents a

summary of the purpose and a view of the wide field of application of the methods (20).

These methods are the logical ones for study of affection. Pleasantness and unpleasantness are attitudes. They are attitudes that people hold toward situations relative to their behavior tendencies of seeking or avoiding.

Thurstone has himself applied the method to affective judgments. Although his publications have received attention almost solely as application of a methodology, many of the studies actually belong in the experimental work on feeling. He defines an attitude as "the affect for or against a psychological object" (20, 261). And his whole discussion and treatment of attitudes assumes the judgmental conception of feeling. He has demonstrated how an abstract affective continuum or scale can be constructed, psychological objects allocated thereon, and changes in affective value resulting from social influences measured. It is now possible to study affective judgments of complex behavior situations, by means of verbal surrogates, and not merely odors, colors, tones. Our strongest affects, after all, are toward behavior situations and not toward Bradley colors.

Thus pleasantness and unpleasantness are given definite theoretical status by the judgmental conception, are allocated to the field of values, and find there a perfected method for precise quantitative investigation.

Summary

Pleasantness and unpleasantness, according to Carr's theory, are judgmental reactions to psychological objects which imply that the judger normally possesses either a positive or a negative reaction tendency toward them. The essential features of this conception are: (1) that pleasantness and unpleasantness are dependent indirectly on reactions and the determinants of reactions; (2) that pleasantness and unpleasantness are judgments; and (3) that there are no conscious contents peculiar to pleasantness and unpleasantness. Experimental evidence can be found for all three of these features.

The judgmental theory answers the introspective problems of feeling and accounts for the prevailing confusion among the results.

It fits the facts of feeling as a functional process and reveals the true nature of the paramount problems. The theory explains the striking dependence of feelings upon training. It illuminates the problem of the relation between feeling-tone and memory. It clearly distinguishes between the affections and the effects of actions.

The judgmental theory specifically implies (1) that feeling and fulfillment of motive are indirectly related, (2) that feeling depends upon memory, rather than memory on feeling, and (3) that Freud's theory of forgetting is not incompatible with fact.

The judgmental theory is in general accord with the three present-day trends in studies, experimental and theoretical, of the affections. These three trends are: (1) avoidance of the content attitude toward the problems; (2) identification of feeling with meaning; and (3) the basing of pleasantness and unpleasantness upon reactions. Account is taken of Nafe's finding of a correlation between affection and pressure sensations—the exception to the first of these trends; Young's criticisms of the second trend are refuted; and a critical analysis is made of McDougall's theory—the outstanding theory, representing the third trend.

Carr's theory is experimentally verifiable, and, furthermore, indicates the quantitative, experimental method appropriate for investigating pleasantness and unpleasantness. Systematically, pleasantness and unpleasantness are meanings and are allocated to the field of value judgments.

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MACHINES THAT THINK—A FURTHER STATEMENT

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Mechanical servants that will perform their duties without being directed or adjusted or preset as ordinary machines need to be may soon be possible as a result of recent research which aims to endow machines with intelligence of the sort possessed by living creatures.

This fascinating possibility, however, is of secondary importance to the implications that such machines will hold for psychological theory. It is hoped that it may be possible to test the various psychological hypotheses as to the nature of thought by constructing machines in accord with the principles that these hypotheses involve and comparing the behavior of the machines with that of intelligent creatures. Clearly, this synthetic method is not intended to give any indication as to the nature of the mechanical structures or physical functions of the brain itself, but only to determine as closely as may be the types of function that may take place between 'stimulus' and 'response' as observed in the psychological laboratory or in ordinary uncontrolled learning and thinking. Only analogies which will work when elaborately executed are sought, not imitations of nerve, brain, and muscle structure.

In 1933, under the title, 'Machines that think,'[1] the writer gave an account of several attempts to illustrate principles of modern psychological theory by mechanical analogies, and one machine, capable of learning the way through a simple maze, was described in some detail.

Since then various improvements have been made in intelligent machines. Some experimenters[2] have equipped

[1] *Scientific American*, 1933, 148, 206–208.

[2] Norman B. Krim, recently a graduate of the Mass. Inst. of Tech., has placed an account of his work on file in the library of that institution.

their models with distance receptors in the form of microphones and photo-electric cells. New memory mechanisms are being tested. The present article is intended to show how the ability to discriminate stimulus patterns and to respond in 'patterns' can be given to machines together with learning ability, and to suggest how machines embodying the memory principle can be made useful.

Figure 1 shows two views of an improved 'memory cell.' A glass needle is attached to the armature of a solenoid

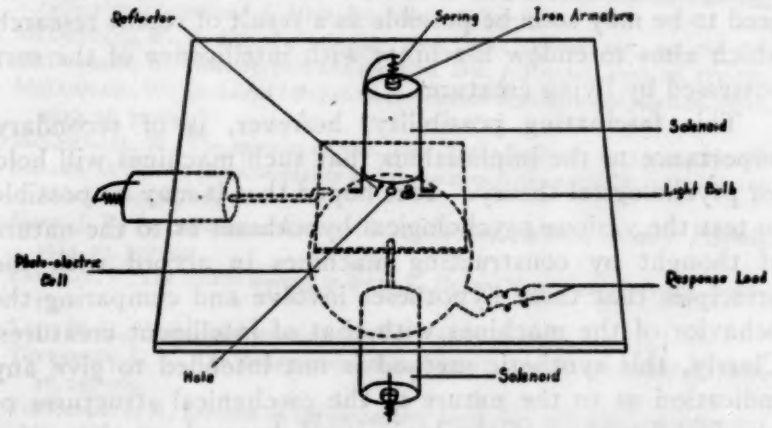

FIG. 1(*a*). Perspective.

MEMORY 'CELL'

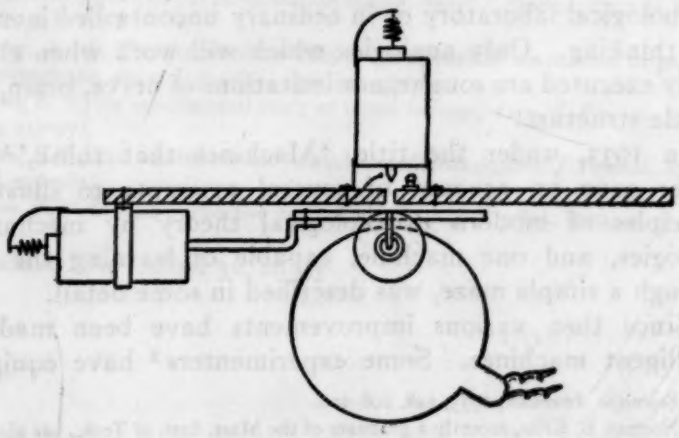

FIG. 1(*b*). Side view.

which is so mounted that when the solenoid is energized the needle will pass downward through a hole in the surface below. Passing through this hole, the needle will perforate a piece of paper immediately beneath, the point at which the paper is penetrated being determined by its position relative to the hole in the surface above it. This paper is carried on the ends of rods extending from the armatures of two solenoids. This mounting allows the paper to be moved to-and-fro beneath the hole by varying the current passing through these solenoids. Beneath the movable paper, and shielded from all external light, is a photo-electric cell. Light can reach this cell only when a hole pierced in the sheet of paper is directly below the hole in the adjacent surface.

The neutral stimulus leads, or wires, those which call for no definite response prior to conditioning, are connected to the solenoids which move the sheet of paper. The dominant stimuli control the solenoid which moves the glass needle, the response being brought about by energy flowing through the photo-electric cell when the needle piercing the paper admits light to the cell. After the paper has been pierced at some point, the response can be again called forth by duplicating the intensities of the neutral stimuli which were effective at the time of conditioning, for such duplication will cause realignment of the hole in the paper with the hole in the surface, with consequent passage of light to the photo-electric cell.

It will be readily seen that the response controlled by the photo-electric cell can be conditioned to a number of stimulus patterns proportional to the number of holes that can be pierced in the paper without crowding.

By using two memory units it is possible to obtain simple response patterns. For instance, if a stimulus pattern is impressed upon the neutral stimulus receptors of both units, these units can both be conditioned to respond to recurrence of the stimulus pattern, or either one alone can be conditioned even though the pattern of neutral stimuli is impressed on both units. Thus, three response patterns are possible with only two memory units. Increasing the number of units will greatly increase the possible number of response patterns.

There is no reason that a number of penetrable sheets of paper and dominant stimulus solenoids with their needles should not be arranged about a single photo-electric cell as shown in Figure 2. If each sheet of paper were large enough to accommodate a hundred punctures (a number not exces-

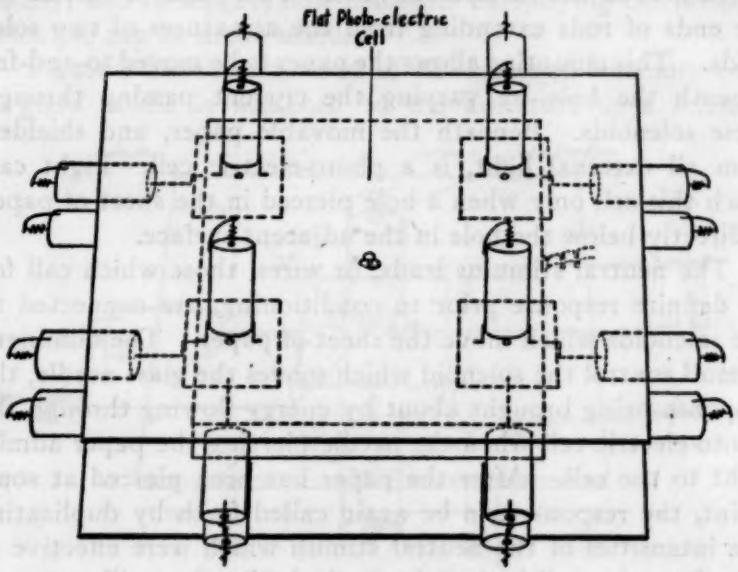

FIG. 2(*a*). Perspective.

EIGHT-IN-ONE MEMORY UNIT

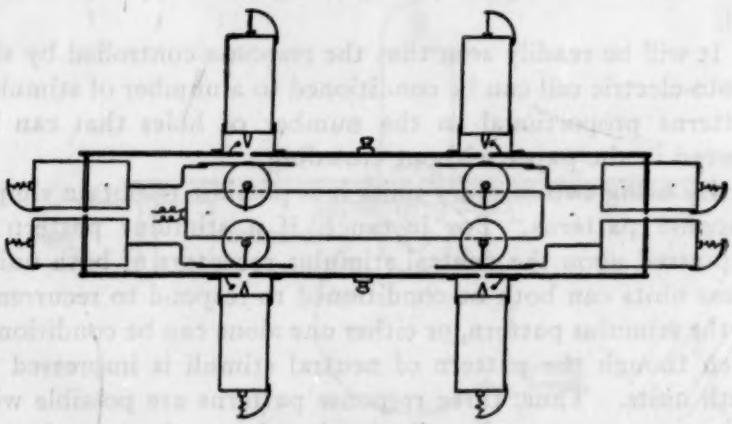

FIG. 2(*b*). Side view.

sive), eight sheets of paper could accommodate 10,000,000,000,000,000,000 combinations of perforated designs, the number being derived by consideration of the fact that for each of the hundred positions that a given sheet of paper can occupy, some other sheet can occupy a hundred more, a third sheet can occupy a hundred positions for each combination of positions occupied by the first two, and so forth; though, of course, no such number of memories could be held all at one time.

If all the needles of the dominant stimulus solenoids in one unit descend at once while a neutral stimulus pattern is impressed upon the appropriate receptors, the photo-electric cell will respond to the light admitted through all the punctures so formed, but the conditioned response cannot be called forth *with full intensity* thereafter unless the neutral stimulus pattern is completely duplicated so as to place all of the sheets of paper in the positions that they occupied at the time of conditioning. (Of course there is the possibility that parts of two or more conditioned stimulus patterns would combine to produce a response of full intensity; this is a fact of considerable theoretical interest.)

The muscles of the higher animals are so arranged that every muscle has its opposing muscle, one which produces a motion *incompatible* with that produced by the first. This organization is reflected in the workings of the nervous system and in the mind itself. Obviously, if two muscles are not to be used at the same time, economy of energy demands that stimulation of one shall cause the other to be relaxed. Consequently, the working of any ordinary brain is such that when one group of cells favoring a particular response becomes more active than groups favoring incompatible or unrelated responses, the first group inhibits the activity of the other groups, especially of the group favoring movement incompatible with that which the most active cells tend to produce.

This same principle of dominance must be taken into consideration when a thinking machine is being designed; an electromagnetic arrangement for shorting out the less active

of two memory units of the sort described in earlier paragraphs is shown in Figure 3. It is to be noted that if the more weakly active unit should rise in activity until it surpasses the formerly dominant unit, it will be able to inhibit that unit when reestablishing its own control of the appropriate 'muscle' or corresponding mechanism.

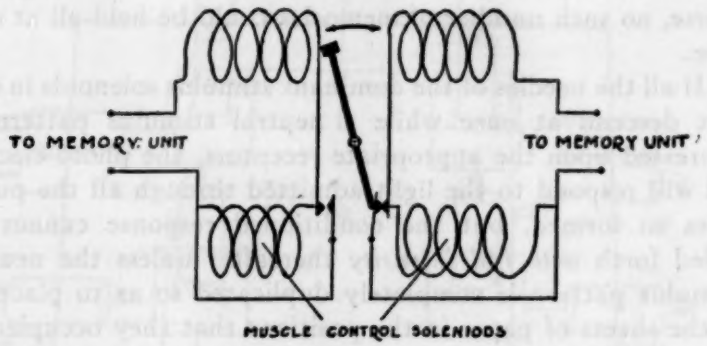

FIG. 3.
INHIBITORY MECHANISM

So far, very little has been said of the neutral stimuli. Of course, stimuli received through the eye and ear as well as those produced by contact with ordinary objects are largely of the neutral type, calling for no definite response until after conditioning. These are well known. Very important, too, but less well known, are the kinesthetic stimuli, those arising from movement and tension of muscles and tendons. Patterns of these stimuli are to some extent involved in every conditioning or memory impression of intelligent creatures and greatly facilitate recall of memories involving objects out of the range of perception in the environment. This is evidently so, for the kinesthetic elements of any stimulus pattern can obviously be supplied by the organism itself at any time, regardless of external circumstances (or almost so).

When all of the points set forth here (and a few more!) are properly taken into account in the design of a thinking machine, the result should approach the ideal of a mechanism which will exhibit behavior which even the most skeptical

must recognize as intelligent. The machine will have many memory units of the sort described in this article. Dominant stimuli will be supplied to guide it in 'first encounters' with potent factors of its environment. Neutral stimulus receptors of visual, auditory, and kinesthetic types will have leads to the memory units. Energy will pass from one unit to another only through kinesthetic leads, though the visual and auditory equipment will have leads to units governing each 'muscle.' Such an arrangement will give the machine highly developed powers of recognizing repeated stimulus patterns, of imagination, and of recall. In order that it shall be able to remember its own 'thoughts' provision must be made for conditioning with conditioned reflexes acting as dominant reflexes. This effect can be partially attained by arranging for 'self conditioning' on the part of any memory unit that shall become dominantly active after having been inhibited. The mechanism for this need not be expounded here beyond the remark that the apparatus for shorting out units that are inhibited can be made to control the operation. Only kinesthetic receptors need be involved.[3]

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[MS. received November 30, 1934]

[3] Some economy in experimental models could be effected by equipping each photo-electric cell to control several responses. This could be accomplished by passing the current from the photo-electric cell successively through several responding members in rapid rotation as might be done by means of a commutator. A slotted disc mounted on the same shaft as the commutator would cause the light activating the cell to pass through a different set of memory surfaces for each position of the commutator.

DISCUSSION

PROFESSOR GRAY'S 'OBJECTIVE THEORY OF EMOTION'

I do not wish to quarrel with Professor Gray's *objective* definition of emotion "as the intense but temporary bodily behavior initiated by some sort of stimulation sufficient to bring about immediate action of the endocrines (and a resultant change in blood chemistry), profound visceral activity, heightened muscle tonus, increased sensitivity, etc." [1] He has a right to arbitrarily define his terms as he pleases, and in the present state of the field his definition would not seem greatly different from nor less serviceable than the others. When he proceeds to arbitrarily define the *subjective* or conscious emotion, the emotional *quale*, as the proprioceptive material furnished by this reaction, he is on less sure ground and I am inclined to disagree. When he goes further and states this subjective definition, not as an arbitrary assumption, but as a statement of fact, and misinterprets the findings of Cantril, Landis, and myself in our work with adrenalin, I feel forced to disagree.

While there were indications in the work of Landis and Hunt that Gray's *objective* emotion was present in most of the adrenalized subjects, there is little reason to believe that the resultant proprioceptive stimulation was accepted by these subjects as a feeling of genuine emotion.[2] The paucity of the introspections obtainable with abnormal cases may have led Gray astray. In the work of Cantril and Hunt on normals, however, adequate introspections are reported.[3] All of the 22 cases in this experiment presumably experienced the proprioceptive material which Gray would identify with the emotional *quale*. Nevertheless, in only four reports was this experience accepted as 'emotion' by the observer. The following report is typical of those four observers who found the mere adrenalin syndrome sufficient to furnish a *feeling* of emotion: "I seem oppressed with a vague fear of something—feeling much the

[1] J. S. Gray, An objective theory of emotion, PSYCHOL. REV., 1935, 42, 108–116.

[2] C. Landis, and W. A. Hunt, Adrenalin and emotion, PSYCHOL. REV., 1932, 39, 467–485.

[3] H. Cantril, and W. A. Hunt, Emotional effects produced by the injection of adrenalin, *Amer. J. Psychol.*, 1932, 44, 300–307.

same as when I've lain awake all night, frightened that Bill might die. In spite of knowing the cause of his illness the fear was not specific and neither is this. I am oppressed with a nameless fear." In ten cases a similarity was noticed between the experience and emotion but identity was denied. The following is typical of these: "Bodily feeling of extreme nervousness. The bodily feeling almost swamps the psychic state, but the nervousness is wholly a matter of physical symptoms. I feel nervous, but I am not nervous. The reason seems lacking." In eight cases the observers report simply the objective symptoms and make no mention of emotion. This is an example: "Trembling, particularly in hands. Voice shaky. Legs trembling. No psychic effects." Since 80 per cent of these normal observers deny that the experience produced by the adrenalin syndrome can be identified with a genuine feeling of emotion, it would appear to be a misunderstanding to maintain that these results fortify the conclusion that "without question . . . changes in blood chemistry do initiate neural impulses which are interpreted by the individual to be emotional feelings." The conclusions of both Landis and Hunt, and Cantril and Hunt are that in most individuals the emotional 'awareness' involves the higher perceptual or intellectual functions and contains cognitive as well as proprioceptive experience. A further investigation of mine on the ambiguity of emotional terms of report would support this contention that the emotional *quale* cannot be traced to any constant proprioceptive experience.[4] Apparently the 'felt' emotion of fear, let us say, may be two different experiences in two different people or in one person at two different times. A feeling of 'fear' may simply involve bodily (proprioceptive if you will) sensations, or it may consist of these plus further material of a cognitive nature, 'reasons,' 'causes,' etc.

Yet whence arises this belief in a common, constant experience which can be labelled the '*quale*' of emotion, and which exists independently of any arbitrary definition? The only common factor running through a series of emotional stimulations which produce the same verbal report in different individuals or in the same individual at different times would seem to be this same verbal report itself. In a series of 20 reports of 'fear,' the actual stimulus situations and the actual experiential materials present in consciousness may differ widely. The only constant factor comes in the

[4] W. A. Hunt, Ambiguity of descriptive terms for feeling and emotion, *Amer. J. Psychol.*, 1935, 47, 165–166.

issuing from these varied causes of a common verbal report, 'fear.' This is simply saying that the individual's report is a conditioned verbal response that may be attached to varying and multiple factors so that its appearance is no guarantee of the presence of a single constant stimulus. This interpretation has proved helpful in explaining some of the confusion existing in the field of affectivity.[5]

However, we have not as yet explained our *subjective quale*. Let us carry our suggestion into the level of conscious experience, and assume that before the issuance of the overt report there is an appearance in consciousness of an implicit verbal response of the same general nature as the final overt one. That is to say, when called on to introspect, the observer, on the basis of whatever raw experiential material may be present, performs an act of cognition (call it judgment, decision, comprehension, apprehension, as you will) the net result of which is the occurrence of an implicit verbal response in consciousness. The observer 'says to himself,' "I am afraid," "This is fearsome," "Fear is present," "Am I afraid? Yes!" This appearance of some implicit verbal response involving the concept 'fear' may then act as a stimulus to the overt verbal response 'fear.' Since the original experiential materials may be different, and the only common factor may be the implicit verbal materials aroused, is it not logical to identify the emotional *quale* with this implicit verbal response? This seems to stand the test of direct introspection, the only test valid for a subjective theory. In my own case, and in the case of the observers of Cantril and Hunt the emotional experience has not the direct immediacy, let us say, of proprioceptive sensation, but involves a secondary, logical process of cognition. On the basis of numerous and varying primary cues there is a secondary process of recognition, and this process of the recognition of emotion involves an implicit verbal response. Since the emotional *quale* arises at the time of this 'recognition' and its attendant implicit verbal response, and since this implicit verbal response seems to be the only constant factor present in the situation, would it not appear that the *quale* of emotion is not to be identified with any simple sensory material, but rather with the implicit verbal response attendant upon the emotional cognition?

There is a resemblance here with Wundt's interpretation of the Weber-Fechner law. Fechner felt that the logarithmic formula was an expression of the body-mind relationship, a direct relationship

[5] W. A. Hunt, The meaning of pleasantness and unpleasantness, *Amer. J. Psychol.*, 1933, 45, 345–348.

between excitatory process and consciousness; while Wundt wished to place the law on a higher level, where it would express the relationship between consciousness and judgment, between the primary materials of experience and the result of apperception. Whereas most of the older subjective views of emotion, including Professor Gray's, would tend to correlate the emotional *quale* with elementary sensory or thalamic cues, the above theory would correlate it with the higher cognitive processes.

The net result of this view would be to place the study of the emotional *quale*, not in the field of emotion proper as we study it today, but in the field of the higher mental processes. Certainly the progress attained in emotion through a subjective study of the conscious experience involved has been small in comparison with the material developed through the objective approach. To say that the subjective approach has been a handicap to the study of emotion is no exaggeration, particularly in view of the thousands of words written, and still being written, in connection with the James-Lange theory. If this correlation of the emotional *quale* with implicit verbal responses did nothing but free the field of emotion from some of the confusion involved in the subjective approach it would be helpful.

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